POWER PLANT ENGINEERING

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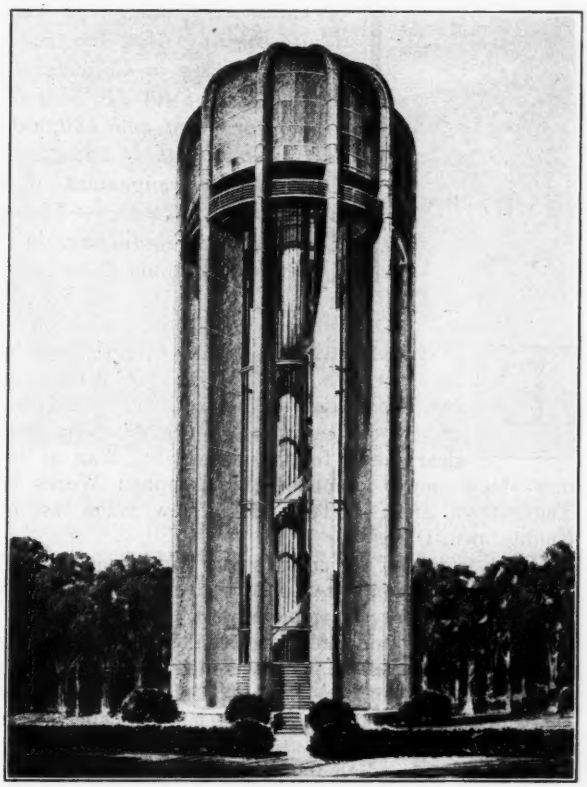


Utility Shakes Hands with Beauty

ROMANCE SUPREME hung around the old oaken bucket; so did typhoid germs and moss and rusted hoops and decayed staves and mosquito-breeding mud puddles and beetles and bees, both honey and bumble. If we must pay the price of poor health in order to have romance, give us neither. The old town pump with its bevy of flirting water maids is, we fear, doomed to history except in grand opera. But who cares when the powers that be in cities, villages and industries have substituted a monument for a hole in the ground, pure, refrigerated water for stagnant earth juice, drinking fountains for tin cups, landscaped lawns for horse-hitching lots. We are sure romance will not decay nor diminish when utility shakes hands with beauty.

Sponsored by the Chicago Bridge and Iron Works, an international competition to develop an aesthetic improvement in the character of elevated water tanks brought forth the drawing reproduced above from Eugene Voita who was awarded first prize. A thing of prominence calls for a touch of beauty.

The Youngstown Sheet & Modernizes Its Power

At Campbell Works, Replacement of 85 Old Boilers by Six Modern Units Burning Blast Furnace Gas, Supplemented by Pulverized Coal Resulting in Concentration of Steam Generation in One Plant—Use of 400-Lb. Steam Only in New 36,000-Kw. Turbine-Generator Plant and 180,000 C.F.M. Turbo-Blower Plant with Evaporators Making 150-Lb. Process Steam in Closed Feedwater Circuit — Rearrangement of Water Pumping System Handling 86,000,000 Gal. a Day—Electrification of Steel Mill Drives,—All Lead to Great Reductions in Costs of Making, Distributing and Utilizing Steam and Power.

ECONOMIES AND ADVANTAGES gained by modernization of facilities for generation, distribution and utilization of steam and electric power in industry are nowhere more clearly and forcibly illustrated than at the new steam power plant of the Campbell Works of Youngstown Sheet & Tube Co., a few miles east of Youngstown, Ohio.

Replacement of the entire steam and power generating and distribution system was involved in building this new plant, which was completed last year. As a result, many important economies have been obtained. By using blast furnace gas as the principal fuel, supplemented by pulverized coal, and by concentrating the burning of fuel and generating of steam in one modern boiler house, old boilers—with total capacity of 39,418 hp., have been replaced by six modern 400 lb. units, capable of developing 36,000 hp., effecting large savings in fuel—besides concentrating the steam generating capacity at one boiler house compared with four before this construction took place.

Replacement of steam drives in the mills by electric drives has also been carried out and electric power for these can be generated economically by a two-unit 36,000-kw. condensing turbine-generator plant. Three new turbo-blowers replace the former piston type blowers and the resulting concentration of steam use in turbines leads to important economies. A large battery of evaporators supplies 150-lb. steam for process work and enables the boilers to work on a closed cycle with pure feedwater. The plant pumps about 86 m.g.d. of service and condensing water, five times as much water as is consumed daily by the city of Youngstown itself.

One of the spectacular features of the new boiler plant is the combustion control system. Under normal operating conditions, this system permits automatic operation of the boilers but the control can be changed instantly to manual as will be explained later.

Need for New Plant

The old equipment had been gradually built up to keep pace with the development of the works (which originally made wrought iron only), to the present one, which makes in addition both Bessemer and open hearth steel. The mill drives were steam engines and the steam boilers were naturally located near the points of heavy demand for steam and were widely separated. Developments in the efficient burning of waste gas from blast furnaces, under high pressure boilers, together with the application of electric drives, made it possible to con-

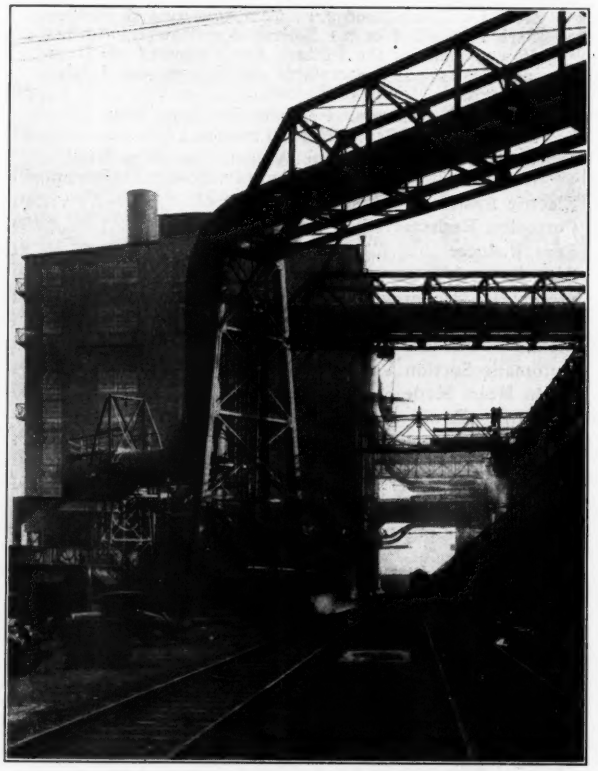


FIG. 1. GENERAL VIEW OF BOILER HOUSE SHOWING BLAST FURNACE GAS AND STEAM MAINS

Tube Co. Plant

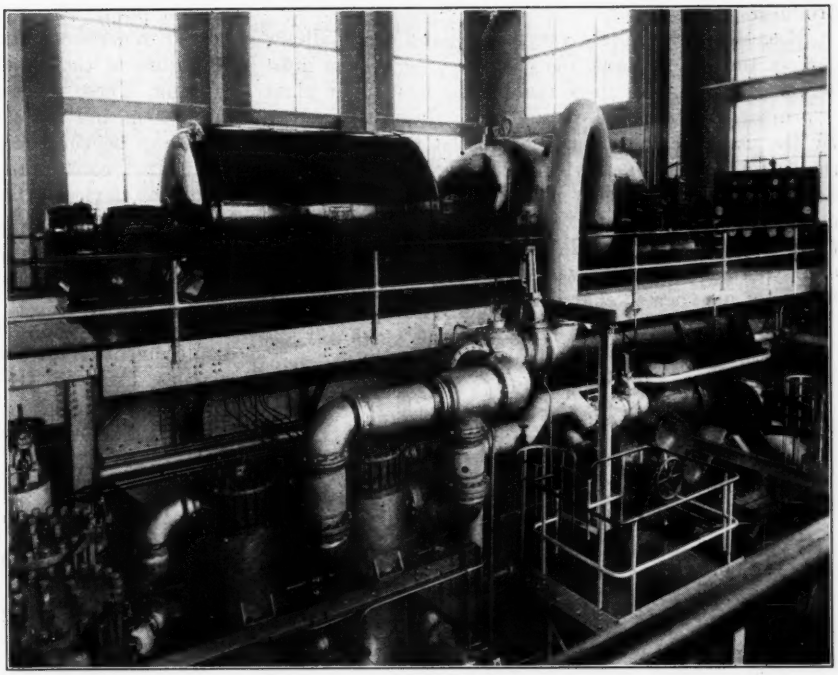


Fig. 2. One of the Two 18,000-Kw. Condensing Bleeder Turbine-Generator Units Which Supply Power to the Electrified Steel Mill Drives. All Power Plant Auxiliaries Except Emergency Boiler Feed Pumps Are Motor-Driven

centrate the steam generation in a single boiler house. The old blast furnace boilers had reached the end of their useful life and advantage was taken of the necessity of replacement to utilize the developments in the use of pulverized coal and to combine the use of both gas and solid fuel in the same boiler furnaces. This policy resulted in plans for the ultimate abandonment of the old steel mill boiler house, although the boilers were still in good operating condition. These changes were justified by the saving. The coal alone consumed at the Campbell Works in the old boiler plants was about 300,000 t. per year. This figure indicates the magnitude of the expense in a general way; of course, the amounts vary from year to year as the steel production changes.

After careful survey of all expenses of operation of the old plant and comparative estimates of the performances of various alternates for new equipment, the reconstruction program was laid out to include the following main items: modern high-pressure boiler plant of 12,000 nominal boiler horsepower, capable of developing 36,000 hp. at steam pressure of 400 lb. per sq. in., steam temperature 700 deg. F.; turbo-blowers for three blast furnaces; gas washers at all blast furnaces washing all gas for stoves and boilers; new turbine-generator plant containing two 18,000-kw. units; new pumping and screening equipment for condensing and general mill service water.

The plans for all the main mills in the Campbell Works included the substitution of electric drives in place of steam engines. Electric drives have been used for furnace doors, air compressors, hydraulic pumps and, in fact, for every auxiliary capable of using electric power.

To bridge the period of change from steam to electric power and to supply such apparatus as will still require low pressure steam, a large battery of evaporators has been installed. These units provide 150-lb. steam in exchange for the equivalent amount of 400-lb. steam, which is condensed and returned to the main boilers. The 150-lb. steam is delivered to the old steam mains for general purposes.

As a result of this concentrated power system, the new boilers are fed entirely by the condensate from all units, which are driven by steam from the new boiler house. The feedwater is heated by steam bled from the main turbine units at various stages.

This system of distilled condensate feedwater is in line with the practice of the modern central station and has the advantage that the boilers are not subject to any dangerous effects due to operating at high ratings with impure water. Loss of water by leakage is compensated by a makeup condenser system, which serves one of the main pump houses, using 150-lb. steam from the low pressure mains and the condensate provides the makeup water. Ample storage is provided for the distilled makeup water. The system is carried to a logical conclusion by the return to the boilers of all drips from the steam headers.

The alternate means of heating the feedwater by economizers was discarded in favor of air preheating. This system leaves the way open for the future use of waste heat for feedwater purposes if this becomes desirable.

Waste-Furnace Gas Makes Cheap Power

Provisions for extreme economy in the use of fuel would not be justified beyond the point where the waste-furnace gas alone would furnish all the steam required for the blowers, electric power and general purposes. This limit will not be reached even after the main mill drives are electrified and the increasing use of waste furnace gas to displace producer gas in mill furnaces points to the continued use of coal in the main boiler

plant, where it may be burned at lower cost than in producers.

Because of the widely varying demand for auxiliary fuel in the boiler plant, the coal burning system must be very flexible. For these reasons the new boiler plant is provided with a coal storage and pulverizing system. By the use of an automatic combustion control system, the boilers are supplied with furnace gas fuel up to the limit of the blast furnace net output. Coal will not be used unless the demand for steam calls for more fuel than the waste gas is able to supply. The disposal of coke oven gas and other waste fuels is also provided for in case of unexpected change in local conditions.

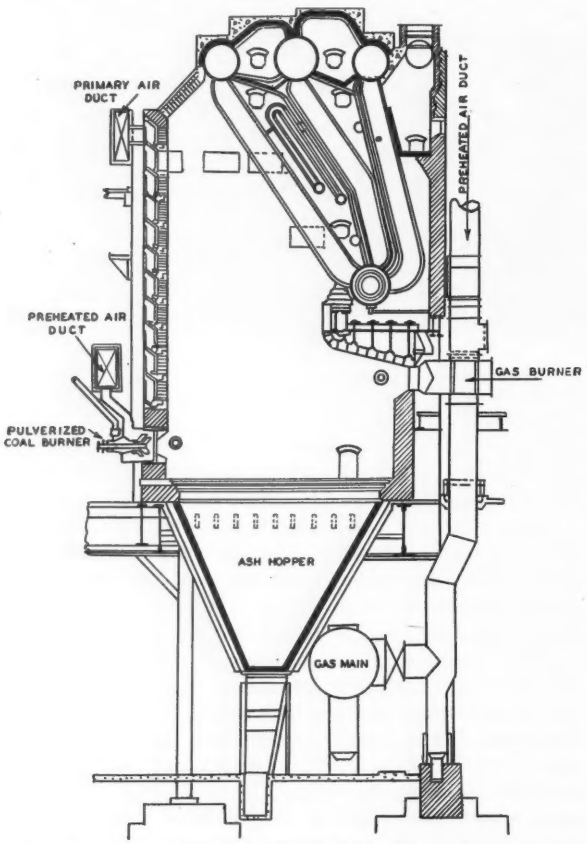


FIG. 3. GENERAL CROSS-SECTION THROUGH ONE OF 20,000-SQ. FT. BOILERS

Since the waste gas from blast furnaces may always be depended upon to make the larger part of the steam, it is evident that the cost of electric power will be low and, even when coal is burned, with the same boiler equipment, the cost is still below that of power generated from a strictly coal fired power plant. These considerations led to the installation of a turbine-generator plant of sufficient capacity to make use of the visible supply of furnace gas, with provision for further units in case of economic need for them. Desirability of maintaining the closed system of distilled water feed and high steam economy led to the use of motor-drives for all auxiliaries, excepting only the emergency boiler feed pumps. Reliability has been obtained by duplication of all essential auxiliaries and by duplicate electric duct systems.

There are two independent sources of electric power; i.e., the new turbine-generators and a connection to the outside public service lines. Essential motors are arranged to connect automatically to a live circuit in case of failure of the circuit on which they may have been running. These precautions call for a elaborate switching system and the controls are in duplicate since any unit may be controlled from its location or from the centralized control room. The principle of controlled automatic devices extends to main steam valves, pumps, blast gates and other parts of the system. Motor-operated valves are used throughout the entire system.

Savings From Concentration

Completion of the new plant will result in the entire displacement of the following boilers:

Blast Furnace—34 boilers of 502 hp. each, or 17,068 gas fuel.

Steel Plant—25 boilers of 464 hp. each, or 11,600 coal.

Puddle Mill—25 boilers of 250 hp. each, or 6,250 waste heat.

The total is 34,918 b.hp. There will also be displaced about 4,500 b.hp. at the nearby Struthers plant or a grand total of 39,418 b.hp. Further extension of the general plant will displace others of the old boilers as they become aged.

Installation of new furnace blowers has displaced four piston blowers with steam cylinders 49 in. and 90 in. diameter and two air cylinders 96 in. diameter, 72 in. stroke. One old turbo blower, operating on 150 lb. steam, is retained for service as a spare. The three new blowers each have a capacity of 60,000 c.f.m. of air at 18 lb. pressure, which can be increased to meet future demands.

In the new pumping system, the condensing water is pumped through the condensers directly into the suction of booster pumps, which deliver the water into the service mains without loss of head. The total pumpage will be reduced by about one-half as compared to the old system, which pumped the condensing water separate from the service water.

The turbine generator plant will replace all of the present alternating current 25-cycle turbine generators, which will be used only for spare capacity, through a frequency changer, for the 60-cycle equipment. All new electric equipment is for 60 cycles and the frequency changer may be used to convert in either direction if desired. The direct current supply will remain unchanged.

Details of New Boiler Plant

The site of the new boiler plant was dictated by location of the four blast furnaces. It is located parallel to the blower house, from which it is separated by three railroad tracks, and coal may be brought in on either of two tracks leading directly from the main lines into the plant. To avoid congestion at this point, the basement of the boiler house is built with a center aisle through which standard railway clearance is provided and this gives room for four main service tracks into the steel plant. The coal hopper is under two tracks and five cars may be held in storage on one of these tracks.

Each furnace has its own gas main which connects to a ring header in the basement of the boiler house. This ring header may be divided by water seals so that each side may be used alone, to permit cutting off either side

for repairs or cleaning. The gas burners are connected through individual Kling Weidlein goggle valves, thus any burner or an entire boiler may be isolated from the gas main. Goggle plates are provided in case of extensive repairs. Supply of gas to all boilers is controlled by two main butterfly valves, one at each end of the boiler house. These valves are controlled by the combustion control system. Suitable drip pockets are provided and the two main water seal valves also function as separating drip pockets. Each burner gas main has a drip pocket directly under the riser to the burner.

The boiler house proper is of structural steel covered with double corrugated protected copperoid steel sheets

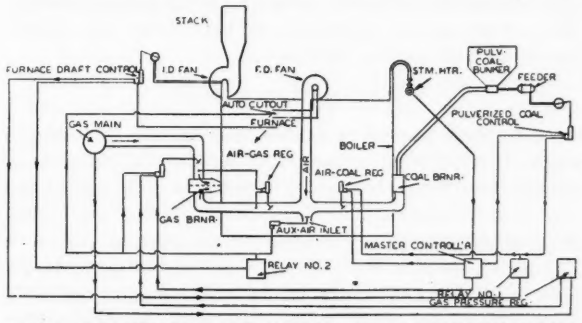


FIG. 4. DIAGRAM OF THE AUTOMATIC COMBUSTION CONTROL GOVERNING SUPPLY OF BLAST FURNACE GAS AND PULVERIZED COAL TO ONE BOILER FURNACE

with insulation between, a design developed by The Youngstown Sheet & Tube Co. This type of wall is a better heat insulator than a 9 in. brick wall. The roof is of precast concrete slabs, and the main floors and galleries of reinforced concrete.

The ventilating system provides for drawing combustion air from the open basement in warm weather; by dampers this can be changed in winter so that the combustion air is drawn downward from the monitor on the roof. Thus the heat radiated from the boilers and flues is brought downward to keep the firing floor at a reasonable temperature. The warm air is returned to the boiler furnaces through the air-cooled furnace walls. In hot weather, the heated air is allowed to escape at the monitor and, by adjustment of the floor dampers, as much fresh air as is desired may be admitted to firing floors. All flues for hot gas are thoroughly insulated. The installation of steam heat is thus avoided except for the lavatory.

Boiler Settings

Boilers arranged in a double row are suspended from the building frame by loops around the three upper drums. The furnace brick work is of the suspended type and its supporting steel work rests upon heavy air-cooled girders at firing floor level. Air circulation across these girders is positive and forms a part of the air cooling system of the settings. Boiler settings are independent of the framework of the building except at the firing floor level. Coal crushing and pulverizing house is independent of the boiler house and separated from it by a brick fire wall.

A passenger elevator serves all these floors; stairways in each boiler aisle, with galleries, serve all boiler auxiliaries. Outside galleries at each main floor provide ready escape in case of accident.

The steam header system is located on the floor immediately under the fan room with vertical and horizontal expansion loop extending upward into the fan room. Sectionalizing valves are all motor-operated and are controlled by a central emergency station as well as at the individual valves.

Six Stirling boilers are set in a double row, as shown in Fig. 3. They are designed for 415 lb. per sq. in working pressure and each has 20,283 sq. ft. of heating surface, with a convection superheater mounted between the first and second bank of boiler tubes, to give a total steam temperature of 700 deg. F. The equipment throughout is designed for 300 per cent of normal rating or 6,000 b.hp. each.

Suspended firebrick furnace walls are air-cooled and the entire boiler setting is completely encased in steel. Air is drawn through the hollow walls of the setting from the firing floor level into the forced draft fans at the upper floor. The air from these fans then passes through a plate type air preheater where it is heated to 560 deg. F., by the stack gases which are drawn through the preheater by the induced draft fans.

Furnaces are 30 ft. wide between side walls and 27 ft. deep at the mud drums, each furnace having a volume of 20,500 cu. ft. Air-cooled, brick-lined ash hoppers are 16½ ft. deep. Each furnace has one cubic foot capacity for each square foot of boiler surface and at 80 per cent boiler efficiency this corresponds to a combustion rate of 12,562 B.t.u. per cu. ft. per hour at 300 per cent rating.

Fuel Burning Equipment

Arrangement of gas and coal burners for the simultaneous burning of gas and pulverized fuel has been the subject of some experiment and a large amount of study. It is evident that the injection of powdered fuel

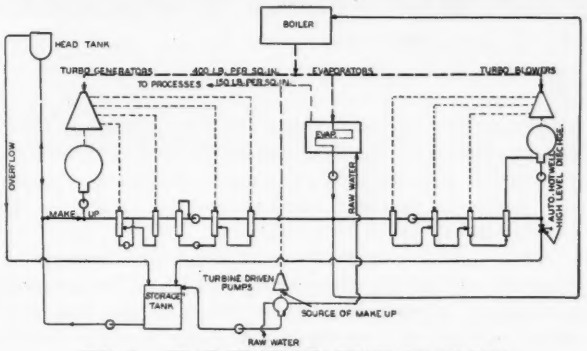


FIG. 5. HEAT FLOW DIAGRAM OF PLANT

into the stream of burnt furnace gas may not meet with success because the gas may burn to a mixture having 22 per cent CO_2 while in the combustion of pulverized coal in well-designed burners and furnaces the CO_2 will seldom reach this value. In other words, the burnt furnace gas may blanket the pulverized coal particles and prevent the necessary excess air from reaching them.

For this reason, the gas burners were placed under the bottom drum of boilers with an arch about 7 ft. deep. The coal burners are placed as far below the gas burners as possible and in this instance were opposed to the gas burners. The short flame type of burner is used and, owing to its location, the excess air may be kept in contact with the burning coal until combustion is complete. Possibility that much of the blast furnace gas may be diverted from the boiler house and be used in mill heating furnaces also led to a design which will permit the removal of the gas burners and possibly to the sub-

stitution of water-cooled walls for the present air-cooled settings for a few of the boilers.

Control of the fuel supply to correspond to the steam demand presented some unusual problems. The supply of waste gas from the blast furnaces would not meet the steam demand at periods of full production in the finishing mills. On the other hand, there is an excess of furnace gas over the week-end. The combustion system was designed so that blast furnace gas alone is used for the higher range of steam pressure. If the supply of gas should not be sufficient the steam pressure would fall to a lower range and within this lower range coal would be burned. A small change of steam pressure is sufficient to cause the pulverized fuel to be turned on to full capacity or be shut off completely.

The result of this control system is that gas only will be burned if the steam pressure can be maintained without the use of coal. The pulverized coal is called upon

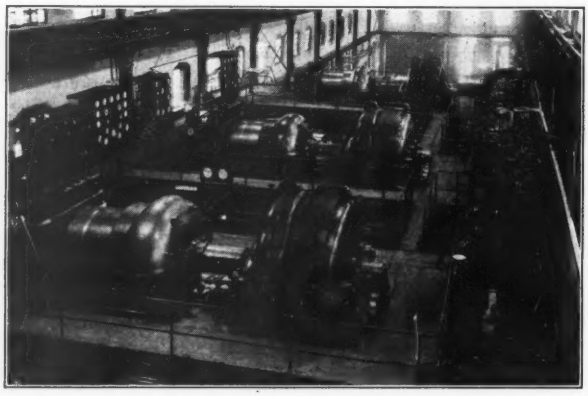


FIG. 6. THREE TURBO-BLOWERS EMPLOY EXTRACTION FEEDWATER HEATING, A NEW FEATURE IN STEEL MILL PRACTICE

only in case of failure to make steam by waste gas. By this arrangement, simultaneous adjustment of gas fuel and coal is avoided. The automatic feature for either coal or gas can be cut out and the control on any or all boilers can be worked by hand.

This control system uses compressed air for the pilot pressure and oil for the power cylinders. The general gas supply is controlled by 10 ft. dia., gas butterfly valves at each end of the boiler house headers. These dampers cannot shut tight but can control the pressure in boiler house mains to suit the steam load.

In case of an excessive demand for gas at the boilers, which would cause the gas pressure to fall below the pressure required at the furnaces for above burners, the control system closes the butterfly valves to maintain a fixed minimum gas pressure at the stoves. In this case the pulverized fuel automatically maintains the steam pressure within the lower range. If the demand for gas at the boiler house is below the output of gas at the furnaces, an automatic bleeder valve is opened at the cold gas outlet of the main gas washers. The maximum pressure can be set to give any desired top pressure on the furnaces.

Adjustment of the gas burners is the usual Steinbart system, but for the sake of simplicity, each boiler has a single power cylinder for the three burners. By this system the air-pressure butterfly valves are automatically set to maintain equal pressure in the air and gas ports. Since the gas pressure is automatically set by the steam demand, the air adjustment follows it and no hunting action can occur.

Coal burners, four for each boiler, are each regulated in two steps. Burners are turned on in the sequence of 1-4-3-2 for one-half capacity each and this sequence is repeated for the second step in capacity. To insure prompt ignition of the powdered coal, coke-oven gas pilots are placed at each side of the furnace. The sequence of control causes the side coal burners to start from these pilots. Effectiveness of the furnaces of these large boilers may be judged from the fact that the 2 in. pilot lights will hold the boiler up to full steam pressure. The control system is flexible and any boiler may be put under manual control instantly.

Safety Precautions

Automatic control of pulverized coal and furnace gas might involve certain danger of explosions under accidental conditions. In case of accidental stoppage of the forced and induced draft fans, the control system closes the gas supply valves to a minimum position which is within the natural draft capacity of the furnace. At the same time, the pressure air duct is closed by a butterfly valve and a free air valve opens so that the burner may work by the aspirating effect of the gas. The air heater is then safe against the accidental accumulation of a gas mixture that might explode. To provide for the proper draft relations where a change is made from gas to coal, or vice versa, speed of induced draft fan and position of boiler damper are controlled by the furnace pressure alone to prevent over pressure in the furnace. If the forced draft fan system should fail when pulverized fuel is in use, the control immediately shuts off the coal, which, of course cannot be fed unless there is a supply of primary air to carry it into the burner. Danger of fan failure is minimized by the arrangement of three independent power circuits as described for other auxiliaries.

New Blast Furnace Blowers

Installation of a new blowing plant to displace old equipment and at the same time to maintain the blast furnace blowers in steady operation presented many interesting problems. The four blast furnaces had been served for many years by four, horizontal, piston type engines, supplemented by two slow-speed turbine blowers.

Space for the new equipment was provided by the removal of one of the piston-type blowers. Building columns were extended and the roof raised to permit the installation of a new crane over the new turbo blowers. The problem of operation during the change was met by a novel arrangement of the first new blower, which can be operated on either 150-lb. steam pressure or on 400-lb. pressure, without change in the turbine. This turbo blower thus became available early in the reconstruction program and replaced two of the piston blowers with a considerable reduction in the consumption of 150-lb. steam. The second and third units are duplicates of the first one but are built for 400-lb. steam pressure only, and a steam temperature of 700 deg. F.

Each turbine is of the impulse type with 14 stages; the centrifugal blower has three rotating wheels and is

water-cooled. Each blower is rated at 60,000 c.f.m. at 18 lb. per sq. in. pressure.

Air intakes had to be located in the narrow space between the old boiler house and the blower house, which was congested by blast mains and steam headers which could not be disturbed. This problem was solved by using three of the old boiler stacks as air intakes.

Blower Condensers and Extraction Heaters

Surface condenser for each blower with 7500-sq. ft. surface, is divided by a vertical partition and either side can be used alone while the other side is being cleaned. Condensing water is taken from the Mahoning River and the water boxes have a butterfly valve control so that the water may be circulated in single or three pass. By this arrangement, a high vacuum has been maintained during the hot summer months. Each condenser has two independent sets of air jets and after condensers and the hotwell pumps are also in duplicate. Condensing water circulating pumps are located in one of the old pump houses.

After the water has passed through the condensers it is picked up by two booster pumps and delivered to the service water lines to the blast furnaces with a considerable surplus for general mill service as will be described.

All auxiliary pumps around the blowers are driven by 60-cycle motors. Wiring for each of the sets of pumps is carried in separate ducts so that each of the independent units has an independent source of power. Control of the condensate and booster pumps is from the boiler house switch room where three independent sources of power are available. Each condensate pump has a corresponding feed pump on the same base plate and driven by the same motor.

Condensate from the condenser hotwell is pumped through a low stage bleeder heater which receives steam from the low pressure end of the main blower turbine. The heated condensate then passes through the boiler feed pump to two higher stages of bleeder heaters and is heated to about 350 deg. before entering the boiler feed system.

Evaporators Make 150-lb. Steam

In the same building with the turbo blowers the battery of evaporators is installed. In consists of six horizontal units, each designed to make 50,000 lb. of 150-lb. steam an hour in exchange for the same amount of steam at 400 lb. 700 deg. direct from the main steam headers. These evaporators are connected as shown in Fig. 5, the six units operating in parallel to supply 150-lb. steam for general mill use and for operating several small turbine generators, pumps and other equipment.

The evaporator feedwater for making 150 lb. steam comes from a filter plant. On its way to the evaporators it passes through a makeup condenser, where it helps condense the 150 lb. steam, which drives the service water pumps. The condensate from this condenser forms the makeup water for high pressure boilers.

The evaporator feedwater is heated by the condensation of this makeup.

The condenser has divided water boxes, so that in emergencies service water from the mill service line can be passed through one side.

Evaporator feedwater, after leaving the makeup condenser, passes through an open feedwater heater, and then through heat exchangers, which cool the evaporator drain condensate, which is on its way to the high pressure boilers.

Evaporator drain pumps in this arrangement are also boiler feed pumps. These take their suction from the discharge of the evaporator coils and send the condensate directly back to the boilers. Three 650-g.p.m., 3-stage motor-driven centrifugals are used for this service.

Changes in Pumping Equipment

The Mahoning River is the source of both condensing and mill service water and the total quantity of water

FIG. 7. PULVERIZED COAL BURNERS AND COMBUSTION CONTROL EQUIPMENT

pumped has reached 190,000,000 gal. a day in the summers of past years, the condensing water being about 45 per cent of total. This quantity is many times more than the total daily flow of the river during the summer months. In the past, the waste water has been returned to the river at various points and a portion was discharged well upstream from the two old pumping stations, therefore it was well cooled before being returned to the condensers. The other portion was discharged well downstream and little cooling was done on this portion.

New pumping arrangements have changed this circulating system so that the water is pumped at low pressure through surface condensers directly into the suction of booster service pumps, thence to the various mills. These mills all lie upstream from the location of the condensers, hence the warm water has a long path down stream for cooling. The arrangement of condensing water and booster pumps results in a considerable saving in pumping costs because the booster pumps pick up the water from the condensers without loss of head.

All the condenser and booster pumps are driven by a.c. motors in such a way that the relative speeds are

Principal New Power Plant Equipment—Campbell Works of The Youngstown Sheet & Tube Co., Youngstown, Ohio.

All auxiliary motors operate at 220 v. except those driving circulating pumps, which operate at 6600 v.

Boilers and Auxiliaries

6 Babcock & Wilcox Co. Stirling boilers, Class XIV, 20,283 sq. ft. heating surface each, designed for 415 lb. gage working pressure. Tubes 3¼ in., drums, 2—42-in. and 2—48-in.

6 Babcock & Wilcox Co. convection superheaters to give steam temperature of 700 deg. F. Superheaters installed between 1st and 2nd boiler passes.

6 Combustion Engineering Corp., air preheaters, plate type, 20,100 sq. ft. each, 210 elements each, 12 ft. by 4 ft.

6 American Arch Co. furnaces with air-cooled suspended hollow walls and arches. Furnace volume, each 21,000 cu. ft.; 1077 cu. ft. furnace vol. per sq. ft. boiler surface.

6 Allen-Sherman-Hoff Co. hopper bottoms and ash gates.

Stacks and Draft Equipment

6 Steel stacks, 10 ft. diameter, supported on roof, top of stacks 104 ft. 5¼ in. above c.l. of pulverized coal burners.

6 B. F. Sturtevant Co. induced draft fans, radial blade steel plate type, 184,000 c.f.m. each at 8.4 in. H_2O Driven by G.E. 450-hp. slip ring motors; speed regulating by rheostats with shaft regulation by combustion control of fan speed and damper.

6 B. F. Sturtevant Co. forced draft fans No. 7, each 198,000 c.f.m. at 13.0 in. H_2O, 300 per cent rating, each driven by G.E. 200-hp. motor at 68- or 350 r.p.m. (165 or 20 hp. respectively) Speed controlled manually.

Fuel Preparation and Burning Equipment

18 Steinbart Co. gas burners, 3 per boiler, pressure type designed to maintain boilers at 300 per cent of rating with 4 in. gas pressure. Control by combustion control operating damper in gas main each end boiler house main, with regulators for 3 burners on each boiler.

24 Combustion Engineering Corp. Couch burners and feeders, 4 per boiler, controlled by steam pressure through combustion control in combination with gas supply control.

2 Combustion Engineering Corp. Raymond pulverizers, each 15 t. an hr., driven by 200-hp. G.E. motors. Exhauster for each mill driven by a 100-hp. G.E. motor.
Combustion Engineering Corp. Screw conveyors, duplex type, capacity each 100 t. an hr.

1 R. H. Beaumont Co. automatic skip hoist and loader.

1 American Pulverizer Co. ring crusher, driven by 50 hp. G.E. motor.
Interlocking control for all coal handling equipment drives.
Allen-Sherman-Hoff Co. Hydrojet ash removal system delivering to settling basin, loco. crane removal. Cameron single-stage pump driven by 5-hp. Reliance motor supplies sluicing water.

Other Boiler Room Equipment

2 De Laval Steam Turbine Co. emergency standby 5-stage boiler feed pumps, each driven by a De Laval single stage turbine, taking steam at 400 lb. and exhausting to atmosphere.

1 Hagan Corp. Combustion Control system. Each boiler has one control board for full automatic or manual control, gas and coal supply controlled by steam pressure. One master board gives complete automatic or hand control on either gas or coal. Draft control by furnace pressure alone by damper and step-by-step fan speed control.
Motive fluid, compressed air or oil.

Feedwater Regulators (Copes)—Northern Equipment Co.

Soot Blowers—Diamond Power Specialty Co.

Steam Piping (ring headers seamless steel tubing with loop expansion bends with Sargol welded joints throughout) ..... Youngstown

Main Stop Valves—Schutte & Koerting Co.

Branch line valves double gate—Walworth Co.

Valve controls (all valves) motor-operated—Liberty Controls.

Turbine-Generators and Auxiliaries

2 Westinghouse Electric & Mfg. Co. turbine-generators, each 18,000 kw., stage designed for 385 lb. gage, 700 deg. F., 24 in. vacuum, each driving a Westinghouse 22,500 kv-a. 0.8 p. f., 6900-v., 60-cycle, 1800 r.p.m. generator with direct-connected 95-kw. exciter.

2 Griscom-Russell Co. generator air coolers, closed system.

2 Worthington Pump & Machy. Corp. surface condensers for above main units, each 25,400 sq. ft., two pass, vertically divided water boxes. Shells 11 ft. 3 in. diameter, spring-supported. Tubes, 4670; 1 in. dia.; 21 ft. long flared and expanded at inlet end; metal packing and ferrules at outlet.

2 Andale Engineering Co. oil coolers.

5 Link-Belt Co. traveling screens.

2 Pairs De Laval Steam Turbine Co. condenser circulating water and booster pumps, capacity each pump 15,000 g.p.m., condenser circulating pump 60 ft. head, booster pump 92 ft. head. Each pair consists of a circulating pump and a booster pump driven by one 750-hp. Westinghouse constant speed induction motor.

2 Worthington Pump & Machy. Corp. steam jet air pumps, each a double two-stage unit mounted on inter and after coolers.

2 Worthington Pump & Machy. Corp. type S.D. 2-stage condensate pump driven by G.E. 50-hp. induction motors.

8 Griscom-Russell Co. extraction heaters, closed type, 4 per turbine, equipped with Atwood & Morrill non-return valves.

4 Worthington Pump & Machy. Corp. heater drain pumps, special double units 2 per turbine. On each turbine, two low stage heaters drain through heat exchanger to Hot Mill; two high stage heater drains mix with condensate. Makeup system includes surge tank with float control of Worthington makeup pump discharging into condensate feed between 2d and 3d heaters. Overflow returns to makeup storage tank.

4 Ingersoll-Rand Co. Cameron 4-R. St. boiler feed pumps, 2 per turbine, each 5-stage, 600 g.p.m., 1160 ft. head, driven at.....r.p.m. by G.E. 300-hp. induction motors, with Mercon Regulator Co. pump governors.

2 Worthington Pump & Machy. Corp. Washout pumps, each 500 g.p.m. drive 7½-hp. Reliance Motor.

1 Worthington Pump & Machy. Corp. screen washing pump. 350 g.p.m., drive 20-hp. Reliance motor.

2 Worthington Pump & Machy. Corp. tube washing booster pumps, 150 g.p.m., drive 25-hp. Reliance motor.

1 Worthington Pump & Machy. Corp. auxiliary oil pump, 150 g.p.m., 5 hp. Reliance motor.

1 Drip system; steam header drains, with release tank, condensate pumped with feed system, vapor to extraction heaters.

Makeup System

Turbine room crane, 75-t.—Morgan Engineering Co.

1 Worthington Pump & Machy. Corp. surface condensers, serving makeup system; surface 7000 sq. ft., divided 1-pass or 3-pass. Source of steam, old service and condensing turbine driven pumps taking steam at 150 lb. from evaporators. Condensing water; normal, evaporator feed water one side of condenser; emergency service water other side of condenser. Condensate forms makeup; amount regulated by adjustment of load on steam and electric driven pumps. Hot well control by gravity.

2 Worthington Pump & Machy. Corp. condensate pumps for above, discharging to two 100,000-gal. storage tanks.

Evaporator Plant

6 Griscom-Russell Co. horizontal evaporators, capacity each 50,000 lb. an hr. of 150-lb. steam (175 lb. max.) when supplied with 400 lb. 700 deg. live steam. Surface 1200 sq. ft., shells 102 in O.D. by 19 ft. 11 in.
Evaporator condensers. Filtered and treated Mahoning River Water serves as condensing medium in makeup condenser and then is fed to evaporators.
Final heating by existing open heater connected to drip system and old turbines.

2 Griscom-Russell Co. drain coolers and feed heaters, 960 sq. ft. each.

3 De Laval Steam Turbine Co. evaporator drain pumps (i.e., boiler feed pumps) each 3-stage, 600 g.p.m., 1160 ft. head, drive 100-hp. Westinghouse induction motors.

2 De Laval Steam Turbine Co. feed pumps for filtered water, each 3-stage 800 g.p.m., drive 150-hp., G.E. induction motors.
Feedwater regulators (Copes)—Northern Equipment Co.
Non-return valves 12-in. cast steel—Schutte & Koerting Co.
High pressure steam piping. Ring type seamless steel. Sargol joints ..... Youngstown
Main high pressure valves—Schutte & Koerting motor-controlled.
Branch valves.....Walworth Co. with motor control.
Control system, 2 Schutte & Koerting throttle valves with distant pressure control.

Blast Furnace Turbo-Blowers

3 General Electric Co. turbo-blowers, each 60,000 c.f.m. of free air at 18 lb. per sq. in. Each unit is a 3-stage compressor driven by a 14-stage steam turbine; constant volume governor with centrifugal limit governor and emergency trip.

3 Foster Wheeler Corp. surface condensers for above, each 7000 sq. ft. with 1575 1-in. tubes 17 ft. long, admiralty metal. Water boxes divided with bypass valves for 1-pass or 3-pass operation.

3 Ingersoll-Rand Co. Cameron condensate and feed pumps, 2 stage and 6 stage respectively. Each pair of condensate and feed pumps is driven by a 100-hp. Westinghouse motor.

2 De Laval Steam Turbine Co. booster pumps, each 15,000 g.p.m., driven by 500-hp. Westinghouse constant speed induction motors.

9 Griscom-Russell Co. extraction heaters, 3 per above turbine.

1 Schutte & Koerting Co. hotwell level float control.
Republic Flow Meters Co. instruments: steam flow, air flow, condensate flow indicator, integrator and recorder for each unit also indicating and recording gages.
S. F. Bowser Mfg Co. oiling system and filters.

maintained. The two booster pumps in the blower house have a capacity of 43,000,000 gal. a day and provision is made for duplication of these units in the future. The pumps in the power house are in duplicate and each unit has a condensing water and booster pump coupled to a motor on a common shaft. This pair of units also has a capacity of 43,000,000 gal. a day.

Five traveling screens are provided at the river bank, therefore no trouble is experienced from trash. The divided condensers are made sufficiently large to carry the full load on one side so that full vacuum can be held with a 7-day cleaning period.

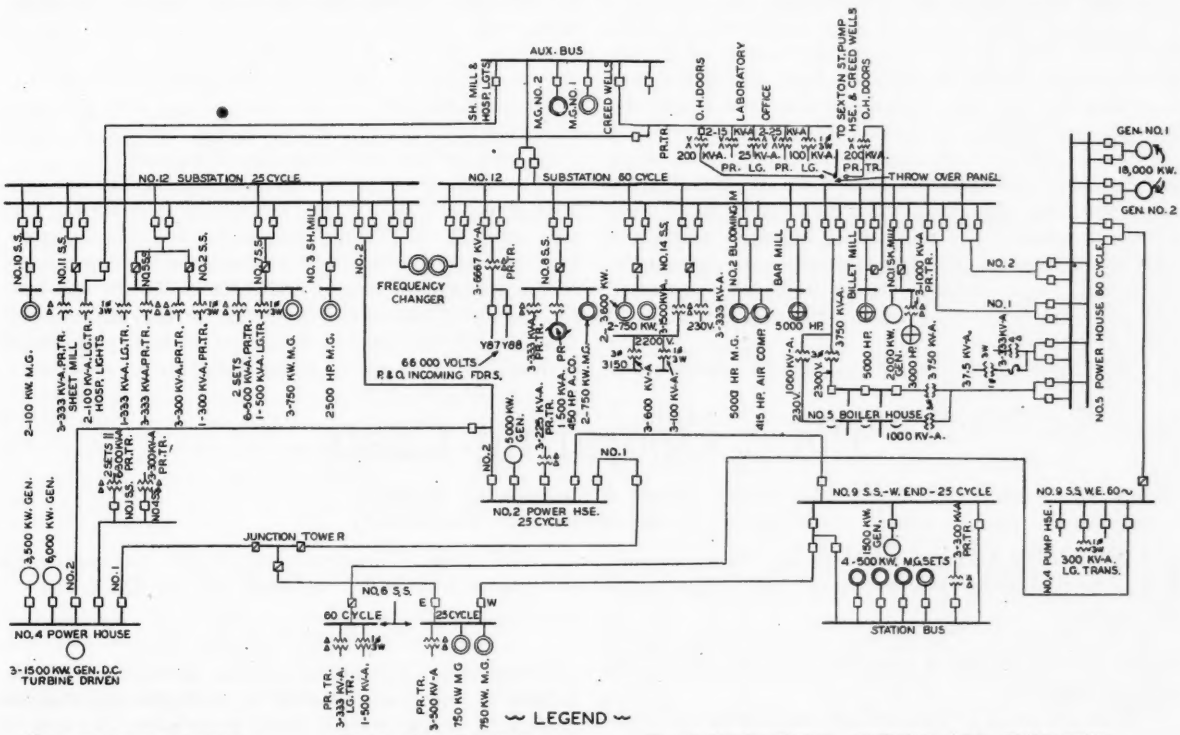


FIG. 8. ELECTRICAL DIAGRAM SHOWS HOW OLD 25-CYCLE AND NEW 60-CYCLE SYSTEMS ARE CONTROLLED FROM SUBSTATION NO. 12

Turbine-Generator Plant

While the new turbine-generating equipment is an important part of the general scheme of modernization noted above, the equipment itself is of standard type and does not require detailed description. The principal point of interest is that here, in an industrial plant, is a condensing plant of 36,000-kw. capacity with four stages of extraction heating the feedwater, the whole following the latest practice as carried out in central stations and in some of the other outstanding industrial plants.

The two turbine-generators, one of which is shown in Fig. 2 are installed in a separate power house near the Mahoning River where the condenser circulation water is pumped through the condensers before going to the mills as noted above. Each unit consists of a multistage Westinghouse turbine with steam extracted at four points, driving a generator rated at 22,500 kv-a., 0.8 power factor, 6900 v., 60 cycles at 1800 r.p.m. This rating depends somewhat on the temperature of the condenser circulating water, which ranges from 40 deg. to 120 deg. F. in the course of a year but the units are considered to be normally 18,000-kw. units. The turbines are designed for 385 lb. gage pressure, 700 deg. steam temperature at the throttle and for 24 in. vacuum. Each unit exhausts to a 25,400-sq. ft., two-pass, divided water-box condenser, spring supported below the turbine.

Boiler feed makeup, prepared as described above, is introduced by a makeup pump discharging into the system between second and third heaters. This pump is under control of a float in a surge tank near the roof and the overflow of this tank returns to the makeup storage tank.

Electrical Equipment

The switchboard shown in Fig. 2 consists of vertical panels arranged in two rows back to back, all relays and recording instruments being located in the back row. The switchboard is in three sections, one for control of 6600-v. breakers, one section for 220-v. auxiliaries and a third for battery circuits and emergency lighting. Practically all the power output of the station is transmitted at 6600 v. to a distribution point in another part of the mill. This tie line is provided with pilot-wire differential relays and also with reverse power relays to operate in case of bus failure. The generator is equipped with differential relays and with short circuit relays for bus failure. No differential relays are applied to the buses.

In addition to the main power feeder there is a line feeding the boiler house and an emergency feeder to a

distribution point at the blast furnaces. These lines are equipped with overload protection. Power for circulating water pumps is supplied from the main buses at 6600 v. All other auxiliaries are supplied with power at 220 v. through transformers fed from the main buses. All outgoing circuits are underground. The duplicate main buses are of 15,000-v. construction and are equipped with surge arresters.

To distribute power through the mill a 40,000-kv-a. central substation known as No. 12, has been built, Fig. 8 showing its relation with the system.

There is a 60-cycle supply of power from the Ohio Edison Co. which is used as a standby source of power. When the load conditions are such that additional power is needed, and during week-ends when there is but one large 60-cycle turbine in operation, the power service is operated in parallel with the Ohio Edison Co. The power that is taken from the Ohio Edison Co. is controlled by automatic load regulation. The two 66-kv. lines from the above company are relayed for balanced power and overload conditions. The transformers have differential protection; the secondary side of the bank is protected with a reverse power relay set to trip at 16,000 kw. in 12 cycles of reverse power.

The output of two 18,000-kw. turbine generators is fed into this station over a separate line and is protected with pilot-wire relays. The two turbine generators are not normally tied together at No. 5 power house but at No. 12 station, giving the operator at the latter full control over output of No. 5 power house.

There is a 7500-kv-a. 60-cycle to 25-cycle frequency changer in the No. 12 substation. This is manually controlled by solenoid-operated oil-circuit breakers and field contactors.

Single-wire diagram, Fig. 8, shows one 3500-kw. and one 6000-kw. turbine generators at the No. 4 power house and at the No. 2 power house one 500-kw. turbine generator. At No. 9 substation there is one 1500-kw. turbine generator. All these units are 25 cycles, 6600 v. These machines are not operated all the time but only when the mill schedule requires. The control of power is handled by the operator at No. 12 substation.

This new power plant was designed for The Youngstown Sheet & Tube Co. by the Dwight P. Robinson Co., now part of the United Engineers and Constructors, Inc., and in connection with the engineering department of The Youngstown Sheet & Tube Co. We are indebted for the use of this article to F. E. Norton, Engineer in Charge of Power, and R. J. Kaylor, Publicity Manager, both of The Youngstown Sheet & Tube Co.

Plant Operating Costs

MATERIALS, LABOR, ALLOCATION OF CHARGES TO SERVICES. BY OTTOMAR H. HENSCHEL*

IN POWER PLANT operation the materials consumed may be fuel, water, electric energy, oils, waste, boiler compounds.

Under the head of labor cost will rightfully appear the salaries and wages of engineers, firemen, oilers, coal and ash handlers.

While the items of maintenance and repair are sometimes presented segregated, it is common practice to combine them.

Referring to the steam generating plant cited previously** we can tabulate operating charges as follows. Materials consumed.

Fuel	$11,833.93
Lubricants and other supplies such as waste and boiler compounds	219.60
Attendance.	
Firemen's wages	1,774.55
Ash handlers' wages	900.00
Engineers' wages	4,231.17
Maintenance and repairs.	
Boiler room equipment	384.70
Engine room equipment	151.12
Refrigeration	281.30
Total	$19,776.37

With this information at hand, the total annual plant cost can be determined. The investment as before noted is $91,400.

Fixed Charges would be:

Interest at 6 per cent	$ 5,484.00
Depreciation as determined	2,407.39
Taxes at 1½ per cent	1,371.00
Insurance at 1 per cent	914.00
Total	$10,176.39

With fixed charges of $10,176.39, and operating charges of $19,776.37, the total will be $29,952.76.

SEGREGATION OF COSTS

Frequently, in a plant of the service type exemplified, it becomes desirable to segregate the various costs such as (a) cost of steam generation, (b) cost of electric energy generation, and (c) cost of refrigeration.

Before attempting this, the following points must be accepted, based on facts as they appear to exist:

Steam generation, electric energy generation and refrigeration, will each bear one-third of the building charges, engineers' wages and cost of lubricants, and other supplies such as waste and boiler compounds.

In this particular installation, exhaust steam is sold to neighboring industrial plants netting the owning company $1,800 a year for which credit is divided between electric energy and refrigeration costs on a 50-50 basis.

STEAM COST

Taking first the item of cost of steam generation, the equipment involved, its cost and rate and amount of depreciation are as shown in the table

TABLE OF COSTS OF STEAM GENERATION

Item	Cost	Depreciation Rate	Depreciation Amount
Buildings	$10,000	0.35	$ 35.00
Boilers	15,000	3.89	583.50
Pumps, auxiliaries and piping	1,100	2.71	29.81

*Consulting Engineer, Milwaukee, Wis.
**Fixed Charges on Power Equipment, July 15, 1931.

Stack	5,000	0.35	17.50
Feedwater heater and piping	1,500	1.26	18.90
Stokers—moving parts	4,000	17.74	709.60
Stokers—stationary parts	2,000	2.71	54.20
Total	$38,600		$1448.51

Fixed charges may be enumerated as:

Interest at 6 per cent on $38,600	$2316.00
Depreciation	1448.51
Taxes at 1½ per cent	579.00
Insurance at 1 per cent	386.00
Total	$4729.51

Operating charges will be:

Fuel	$11,833.93
Lubricants and other supplies such as waste, boiler compounds, etc	73.20
Firemen's wages	1,774.55
Ash handlers' wages	900.00
One-third engineers' wages	1,410.39
Maintenance and repairs of boiler room equipment	384.70
Total	$16,376.77

Total steam generation cost will then be, fixed charges, $4,729.51 plus operating charges, $16,376.77 or $21,106.28.

Tests conducted gave an average evaporation of 7.5 lb. of water per pound of coal burned. Total coal burned during the year under consideration was 4,880,000 lb., so that the total average steam generation for the year may be assumed as 36,600,000 lb. Then the cost of 1,000 lb. of steam was $21,106.28 divided by 36,600,000 = $0.5766.

Electricity Cost

That part of the plant equipment directly used for electric generation may be enumerated as follows:

20 by 36-in. single noncondensing Corliss engine with direct-connected 240-v., 751-amp., 120 r.p.m., 3-phase, 60-cycle alternating current generator; 27½-kw., 125-v., 850 r.p.m. exciter; belted, 125-v., 800-amp., 575 r.p.m., direct-current generator. Cost of the above with freight, installation, piping, wiring, $17,075. Cost of switchboard and equipment, $3,640 or a total of $20,715.

To this must be added the prorated building cost of $10,000, giving the total amount invested as $30,715. Fixed charges will be:

Interest, $30,715 at 6 per cent, $1,842.90; Depreciation: Building, $10,000 at 0.35 per cent, $35.00, Equipment, $20,715 at 2.71 per cent, $561.38; Taxes, $30,715 at 1½ per cent, $460.73; Insurance at 1 per cent, $307.15; Total, $3,207.16.

Operating charges will be:

One-third engineers' wages, $1,410.39; one-third lubricants and supplies, $73.20; one-half repairs to engine room equipment, $75.56; Total, $1,559.15.

Total of fixed and operating charges for electric plant will be, $4,766.31.

To this must then be added cost of steam required to operate the engine.

Tests over a considerable period indicated a mean consumption of 61.5 lb. of steam per kilowatt-hour delivered to the switchboard. The annual electric energy generated was 254,998 kw-hr., or let us say, 255,000 kw-hr. Then, yearly steam requirement chargeable to electric generation would be, 61.5 times 255,000 or, 15,682,500 lb. at a cost of $0.5766 per 1000 lb., the cost of this steam was 0.5766 times 15,682.5=$9042.53.

Summarizing then, we have the following electric energy generation costs:

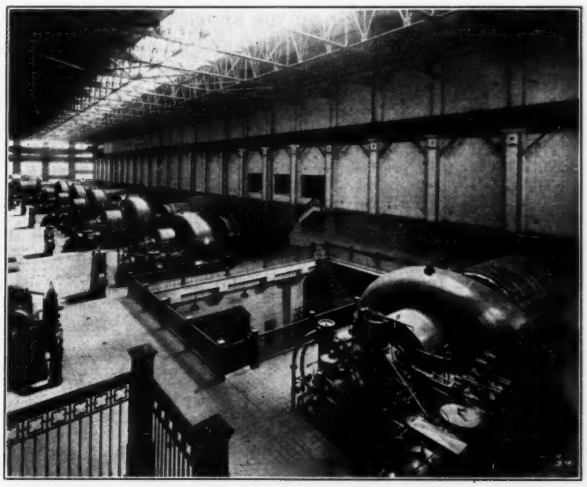
Fixed charges on equipment, $3,207.16; Operating charges, $1,559.15; Cost of steam, $9,042.53; Total, $13,808.84. Credit for steam sold, $900.00; Net cost, $12,908.84.

Rightfully, further consideration should be given to approximately 10,000,000 lb. of steam used each year for process and heating, services indispensable to the operation of the industry and which, therefore, would be required whether the electric energy consumed be purchased or locally generated. The cost of this steam is $0.5766 times 10,000 = $5766, with which the above net cost of electric energy should be credited. Actual net cost may be accepted as $12,908.84 minus $5766 =$7142.84, giving a unit electric energy cost of $7142.84 ÷ 255,000 = $0.028 per kw-hr.

Refrigeration costs may be determined in like manner or, if so desired, can for all practical purposes be obtained by the process of elimination of steam generation and electric current costs from total costs.

Lakeside Station Turbine Room

NOW COMPLETED to its ultimate capacity, Lakeside Station has a total generating capacity of 310,800 kw. in 12 units. Eight of these are low-pressure turbines ranging from 20,000 to 60,000 kw. and four of them are 1200-lb. turbines rated at 7700 kw. Two of these latter are visible on the left-hand side of the far end of the turbine room but the other two are out of sight, one being located on each side of the last low-pressure turbine. The small unit in the left foreground is a house turbine installed in 1920 with the first two turbines. A complete history of this station appeared on page 830 of the Aug. 15, 1931 issue but the above photograph, which was just taken, arrived too late to be included in the article.



TOTAL INSTALLED CAPACITY 310,800 KW.

Improving Plant Performance *by* Condenser Maintenance

Proper Tube Installation and Packing Necessary for Best Results

METHODS OF INSTALLING condenser tube packing vary with the type of packing used. Corset lacing, either plain or treated with paraffin or boiled linseed oil is popular in all parts of the country but is perhaps the most difficult to install by hand. A hand tool for this purpose, shown in Fig. 1, is satisfactory for small condensers but the length of time required and the non-uniform results obtained have led to the development of power-driven tools (air, water and electricity) some types of which allow an operator to pack 12 to 15 stuffing-boxes an hour. One type is shown by Fig. 2.

With the hand tool shown in Fig. 1, a lead or thin fiber ring is first inserted in the stuffing-box and rammed

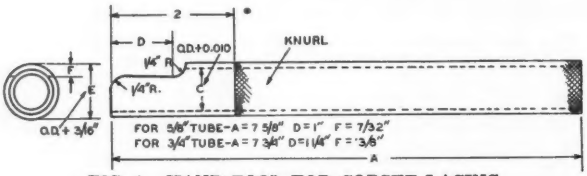


FIG. 1. HAND TOOL FOR CORSET LACING

in place with the cutaway end of the tool. The lace is then threaded through, from the knurled portion of the tool and the end inserted in the stuffing-box with the cutaway end of the tool as before. The tool is then rotated, preferably clockwise, with one hand and struck a light blow each half revolution with the palm of the other hand or with a light hammer or mallet. Another thin washer should be added before the ferrule is screwed in.

Some prefer to plug up the knurled end of the tool and after starting the lace in the stuffing-box, allow it to hang down and gradually wind around the tool. If not watched carefully when doing this, however, the lace will tighten up and go into the stuffing-boxes as a taut string instead of a loosely woven packing as it should be.

Corset lace can be purchased on a reel or, more conveniently, cut to the proper length. This length can be determined by packing both ends of a tube and noting how far the ferrule sticks out. To prevent leakage, the packing should be as deep as possible but if too much packing is used the ferrule will stick out too far, interfering with the flow of water and, if the tube should creep so that all the clearance is on one end, leave the opposite end of the tube entirely out of the ferrule so that the packing would buckle in.

Such conditions are shown by Fig. 3. In the top sketch, A, the ferrule is screwed in too far or rather insufficient packing is used. The tube comes tight against

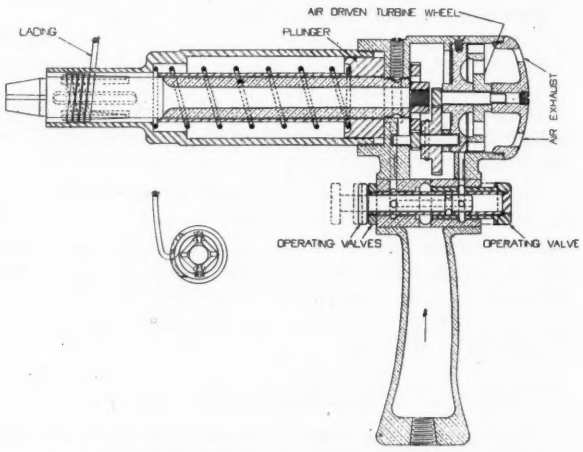


FIG. 2. AIR-DRIVEN TOOL FOR CORSET LACING

the shoulder of the ferrule at both ends, giving no room for tube expansion and preventing the ferrule from compressing the packing so that leakage is not prevented. Sketch B is the opposite extreme. If the dimension X exceeds the dimension Y, the tube may creep and the condition shown by C result with consequent water leakage and possible damage to the tube end. In order to prevent thus, dimension Y should exceed X.

With tubes of such a length that both ends are flush with the tube sheet as shown, the distance X may be as much as ½ in. depending upon the ferrule. Water flowing in creates a venturi effect and a partial vacuum at the space marked Z so that air in the circulating water separates and collects here causing corrosion. In order to

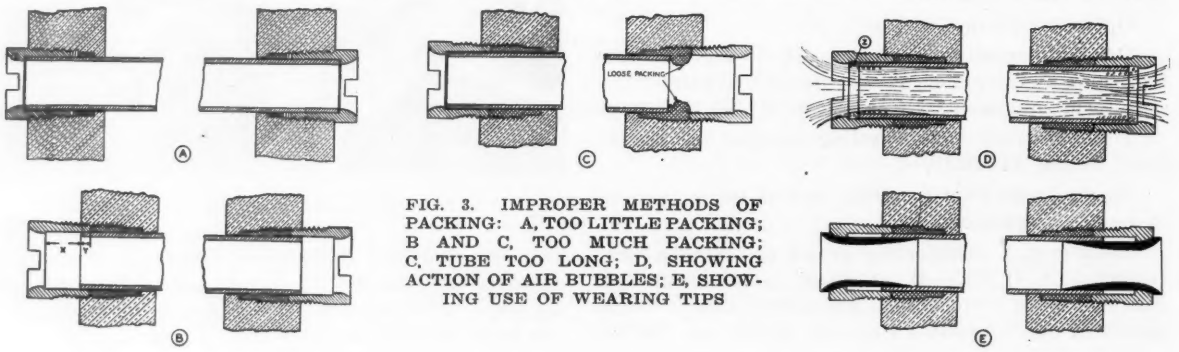


FIG. 3. IMPROPER METHODS OF PACKING: A, TOO LITTLE PACKING; B AND C, TOO MUCH PACKING; C, TUBE TOO LONG; D, SHOWING ACTION OF AIR BUBBLES; E, SHOWING USE OF WEARING TIPS

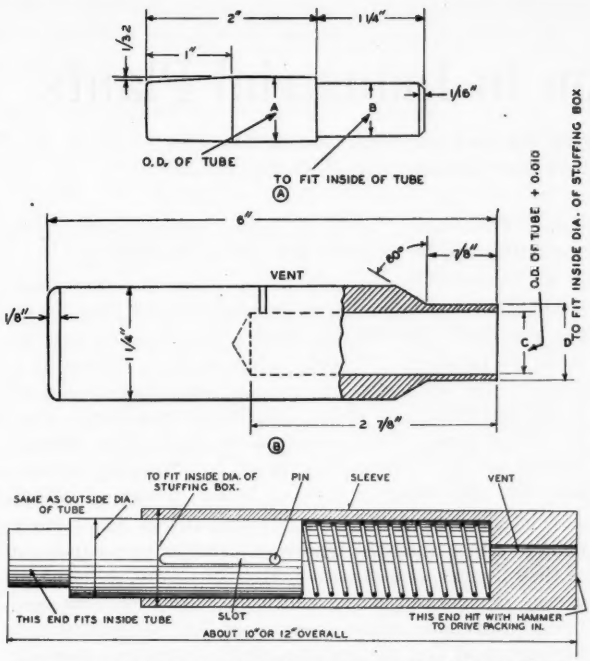


FIG. 4. HAND TOOLS FOR HOSE AND METALLIC PACKING. A, INSERTION PIN (MILD STEEL); B, INSERTION TOOL (TOOL STEEL); C, COMBINED PIN AND TOOL

eliminate this and still have a deep stuffing-box, tubes are sometimes purchased longer than shown in the first three sketches, so as to reduce X to about ⅛ of an inch. Another method widely used to prevent this and protect the end of the tube from corrosion is a wearing tip such as shown in Fig. 3 E. The question of the proper amount of packing is, of course, common to all types, hose, fiber and metallic as well as corset lace.

The corset lace packing tool shown by Fig. 2 operates like a pistol on 70 to 80 lb. air. It is loaded with a lacing, which is shot into the tube plate around the tube and set there by a blow. Looking at the illustration from the left, the tool is a tapered square, followed by a round portion slotted from end to end. To the right is a trigger, much in the same position as it would be in a pistol, and on the front and left side of the handle is a second trigger. In the bottom of the hollow butt is tapped a hole to receive a coupling for the air hose.

The tapered square is inserted in the condenser tube to center the tool. If this portion were left round, the burr often left by the cutting-off machine would prevent proper centering. Just inside the slot, on the cylindrical portion, is a shaft, which, when the thumb trigger is pressed, admits air to a high-speed turbine at the

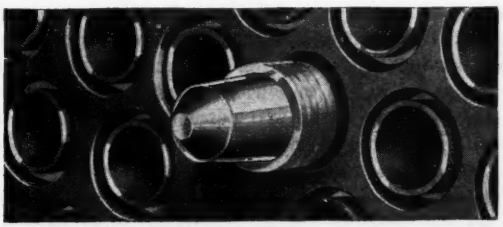


FIG. 5. INSERTION PIN IN PLACE WITH PACKING AT TOP READY TO BE DRIVEN HOME WITH INSERTION TOOL AND HAMMER AS SHOWN IN FIG. 6

FIG. 6. METHOD OF DRIVING HOME PACKING

back. A lacing is cut to length and inserted at the end of the slot, where it is grasped instantly by a spring clamp and wound around the spindle. The second trigger is then pressed, and a plunger which envelops the rotary portion shoots forward, slides the coiled lacing off the rotating part and over the condenser tube, setting it firmly in place. The side trigger is then pressed again, giving a second blow to finish the work.

Tools suitable for hose and metallic packing are shown by Fig. 4 and the method of using them by Fig. 5. (No tools are required for fiber packing. It can be placed by the fingers and the ferrule screwed in on top of it.) The insertion pin is inserted in the tube, a piece of packing slipped over it and then driven in the stuffing-box by means of a light blow on the insertion tool. Corset lace is sometimes installed this way also, by first wrapping it around the pin and forcing it in the stuffing-box as a unit. Because of the loose end, however, it is not a satisfactory method.

Inasmuch as the installation of these types of packing is similar, the following detailed directions applying specifically to metallic packing are sufficient. Both hose and fiber packing come in a single piece; metallic packing, on the other hand, is made up of metallic rings alternated with asbestos or fiber expansion rings.

First an expansion ring is slipped over the insertion pin and pushed into place by the calking tool. A metal ring is then inserted in the same manner and rammed in place by a few light blows of a 1-lb. hammer, as shown in Fig. 6. The blow should not be hard enough to cause tube necking, but sufficient to insure complete removal of all voids. Next insert another fiber and another metallic ring and calk as before. Usually the combination of one expansion, one metal, one expansion and one metal ring is sufficient. If not, additional rings should be installed until the stuffing-box is filled to the desired depth. When ferrules are used, the expansion rings are narrower than when ferrules are not used.*

*See Power Plant Engineering, Sept. 15, 1930, page 1035.

Benson Boiler Five-Stage Evaporator

TABULATED DATA regarding the Benson boiler evaporators at the Siemens-Schuckert Gartenfeld Works, as described on page 791 of the August 1, 1931 issue was left out of the original article and appears below. The water surface of each evaporator stage is 50 sq. ft.

OPERATION DATA OF 5-STAGE EVAPORATOR

Evaporator Stage	Pressure, lb. abs. Heating System	Vapors	Vapor lb./hr.	Output Specific Volume	Loading of Evap. surf. lb./sq. ft./hr.	Loading of surf. cu. ft./ sq. ft./hr.
1	142.2	93.7	4185	4.645	84	396
2	93.7	61.1	4075	7.040	82	575
3	61.1	39.8	3965	10.56	80	854
4	39.8	24.1	3855	16.64	77	1280
5	24.1	14.6	3755	26.90	75	2013

Prevention of Wet Steam in Industrial Plants

FEEDWATER TREATMENT AND CONTROL OF BOILER WATER CONCENTRATION IN ADDITION TO SUITABLE BOILER DESIGN ARE REMEDIES FOR WET STEAM. BY C. D. ST. CLAIR*

ONLY WITHIN the past few years in the designing of new power plants has serious thought been given to the problem of wet steam or boiler carry-over. Previously, efforts were largely confined to the selection of equipment which would produce the desired amount of steam at the highest economical efficiency.

Central power companies first discovered the economic advantages of installing large boiler units and operating at high ratings, but industrial plants were not slow to perceive these advantages and they too started installing fewer units capable of operating at high ratings. Unfortunately their results were not always as satisfactory, for the reason that in their designs insufficient consideration was given to differences in load and feedwater. Their usual difficulties were: loss of superheat; plugged turbine blades; excessive wear in steam cylinders; excessive cylinder oil requirements with subsequent difficulties of removal from exhaust; excessive trap maintenance and fouling of all other steam consuming equipment because of the carry-over of boiler water impurities with steam.

Central station plants as a rule can operate their main units continuously at uniformly high ratings, taking the variations on less efficient units at somewhat lower ratings. Also central station plants have feedwater that is quite free from impurities, being practically all condensate with only a few per cent makeup and this in many cases is obtained from evaporators. Consequently, in the selection of their boilers it was necessary to consider only general features of design and adaptability to other related equipment.

Industrial plants do not always have such favorable load conditions and seldom have less than 50 per cent makeup water, often nearer 90 per cent and quite likely to contain a high percentage of impurities. Because of these different conditions, additional thought should be given to the methods of water treatment and control to insure not only prevention of scale, corrosion and embrittlement, but also to prevent carry-over at high rates of evaporation. Care should also be taken to select the type of boiler best suited to meet these conditions.

CONCENTRATIONS

Foaming and priming are two terms generally used in connection with causes of boiler water carry-over. The former is a condition resulting from the concentration of impurities in boiler water which increases surface tension of liquid and causes steam space to fill with an emulsion of steam bubbles, on boiling. To limit or reduce concentration, it is necessary to waste a certain amount of boiler water containing large amounts of impurities and replace with feedwater containing only small amounts of impurities. Such waste usually represents a loss of water, chemicals, power and heat, (unless special devices are used for recovery) and it is desirable to carry concentration as high as possible to reduce these losses, since at higher concentration more impurities can be removed per unit of blowdown.

In every well managed boiler plant the maximum permissible concentration is determined and blowdowns are regulated accordingly. Such determination can be made by titration of boiler water samples, by use of a temperature calibrated hydrometer and examination of steam samples or by steam calorimeter readings. Factors which most affect the maximum permissible concentration are as follows: Nature of boiler water impurities; size and steaming rate of boiler; design of boiler.

The nature of boiler water impurities has a very marked effect upon the tendency of boiler water to foam as they become concentrated. Most oils cause foaming at a very low concentration and organic or vegetable contaminations also cause foaming at low concentrations. Sewage, mud and silt are also likely to produce foaming and every effort should be made to filter out all such substances from the incoming water.

IMPURITIES

Usual chemical impurities of feedwater consist of chlorides, carbonates, phosphates, and sulphates of calcium, magnesium and sodium. While all of these are soluble to a certain extent in cold water, some are only slightly soluble at boiler temperatures. On this account, they appear in the boiler in two forms, dissolved solids and suspended solids. The latter is usually a finely divided precipitate which causes the water to appear cloudy. These suspended solids in themselves do not seem to be responsible entirely for foaming since it can be shown that when placed in pure distilled water similar solids have little effect upon boiling characteristics. Neither can it be definitely proven that ordinary concentrations of soluble solids are entirely responsible for the formation of a foaming water. It is quite true, however, that a combination of these two factors causes boiler water to foam readily and in proportion to their combined concentration.

That is to say, if the suspended solids are low, the concentration of dissolved solids may be much higher than could be carried if the former were increased or vice versa. The effect of suspended solids depends somewhat on their size. A very fine precipitate may be washed by the action of rising bubbles to the steam releasing surface where the ill effects are most pronounced. In such cases, surface blowdowns are desirable. If a substance is fed into the boiler which will cause the suspended solids to coagulate into relatively larger and fewer masses, these will not concentrate at the surface and a much higher total concentration can be carried without foaming sufficient to cause carryover.

There are certain types of equipment available which continually separate these particles from the main boiler water, depositing them into an outside chamber from which they can be easily blown out. With such

*Works Manager, Erie City Iron Works, Erie, Pa.

devices, coagulants need not be used although with large units operating at high ratings, they assist in speeding up separation.

It is evident that the steaming rate of a boiler also largely determines the maximum permissible concentration without carryover. By steaming rate care should be taken not to confuse with so-called percent of rating. The proper measure of steaming rate for purposes of comparison in connection with the maximum permissible concentration, is the hourly weight of steam released per square foot of releasing surface. The reason for this is, that it is customary for boiler manufacturers to increase horsepower ratings by adding water heating surface without adding steam releasing surface in the same proportion. For example, assume two boilers of similar design, each having same diameter drums operating at 200 per cent rating. One has short tubes and a wide furnace. The other has twice the heating surface with the same furnace width but with longer tubes and a higher furnace. The steam release per square foot of water surface in the larger boiler is double that of the smaller boiler and under these conditions the larger could not be expected to carry the same degree of concentration as the smaller, without carryover even though a casual observer might remark that both were operating at the same per cent of rating.

Boiler Design

Boiler designs also have quite an effect upon the permissible degree of boiler water concentration without carryover. Some types cannot be operated satisfactorily at high ratings unless boiler water concentrations are kept low while other types can be operated successfully at high ratings with quite high boiler water concentrations and no appreciable carryover.

Differences can usually be accounted for in relative volumes of steam space and areas of steam releasing surfaces. In comparing two similarly designed boilers the one having larger releasing surface and steam space will contain a larger quantity of foaming steam bubbles before starting to carry over than the other, consequently higher concentrations can be carried in it when producing an equal amount of steam.

In judging different types of boilers it must be remembered that water levels and steam spaces of a boiler in operation are not always the same as when the boiler is idle. If, for instance, one of the steam drums of a multi-drum boiler fills with water when operating at high ratings, the value of that drum is lost insofar as steam releasing surface and steam space are concerned. It is evident also that any submerged drums contribute nothing to these factors but merely serve as a mechanical means of connecting two banks of tubes.

Not all releasing surfaces and steam spaces are in steam drums. Some types of boilers have tube banks above the water line which contribute materially to both releasing surface and steam space. In such boilers, this additional surface and space seems to be even more effective than those of steam drums, because of the mechanical action of tube walls breaking the surface films of steam bubbles.

Since any boiler will show a carryover when steam bubbles become so near the steam outlet that they are swept out by the steam, it also follows that boilers having the lowest outlet velocity will allow foaming emulsion to fill the steam space more nearly before carryover commences. Such boilers can be operated with higher concentrations than similar ones having higher outlet velocities when producing equal quantities of steam. Any superheating surface within boiler also adds a proportional amount to permissible concentrations since, with such surface, the first few per cent of carryover moisture is evaporated before it leaves the boiler.

Priming

Aside from foaming water there are the mechanical causes for carryover in periodic gulps or slugs and such action is called priming. It is very difficult in cases of slug carryover to ascertain whether it was caused by foaming or priming since with a foaming water the density of emulsion within steam space is higher than steam and at high outlet velocities it sometimes is sufficient to cause a siphoning action which pulls large quantities over with the steam. True priming, however, is a condition resulting from a design of boiler in which circulation in certain tube banks is questionable at certain critical ratings and results in a sudden lifting of water levels. This is noticed more with vertical and inclined water tube boilers than with horizontal water tube boilers. A frequent cause of priming is a sudden demand for steam which causes a drop in steam pressure. In such cases, the water volume swells with the increased size of steam bubbles below the surface and also because of additional volume of steam flashed from the water. If, under these conditions, steam is flashed in the rear bank of a bent tube boiler in which the circulation is naturally down, there is the possibility of flow reversal and water will be spouted upward sufficiently to cause slug carryover or priming.

To avoid this difficulty, some boiler manufacturers have, in recent years, adopted the expediency of feeding water into the rear upper drum of such boilers through a submerged feed pipe which insures cooler water in rear bank than in other parts of boiler, thereby preventing the flashing of steam in this tube bank. Such arrangements of introducing feedwater also tend to insure a higher heat absorption efficiency than in boilers where water is fed to an internal feed pan above water line for the reason in the former case, products of combustion raise feedwater to boiler temperature whereas in the latter case, live steam is used.

Separators

There are a number of devices available for removing moisture and impurities from steam that can be attached either to the interior of boiler or in the external piping. Some of these depend upon lowering steam velocities and baffling to cause steam separation. Others depend upon centrifugal action of whirling steam at a high velocity to separate entrained moisture, and still others depend upon a combination of these two.

All such devices have merit provided they are designed accurately for the conditions they must encounter. For example, if a steam separator were designed to be installed on a boiler, having a maximum flow of 100,000 lb. per hr., 400 lb. pressure, 5 per cent moisture and after installation it was found that at times the pressure was 350 lb., the flow was 125,000 lb. per hr., and moisture was 10 per cent, it is only natural to expect the results

would not be satisfactory. As a rule, boiler manufacturers frown upon the use of steam separators or purifiers in a connection with their product, probably for fear that the use of such a device might indicate a faulty design of boiler. This seems a rather short-sighted policy since such equipment, even if not ordinarily necessary, might be worth many times its cost in saving a turbine or engine wreck in case of faulty operation of water regulator or laxness on part of operators.

When viewed in this light, such equipment should be installed as a safety measure for the same reasons safety overspeed governors are installed on turbines or engine stops on engines. The interest charges on such investment are usually quite cheap insurance.

Water-Cooled Furnaces*

Design and Performance, Especially for Underfeed Stokers. By P. N. Oberholtzer**

BENEFITS, other than increased capacity, resulting from water-cooling are: Protection of the furnace walls adjacent to the fuel bed to prevent adhesion of slag and consequent erosion; durable support for the remaining refractory portion of the furnace walls; provision of access and observation doors without costly wall construction. To gain these benefits, side wall water cooling must be carried high enough to prevent adhesion of slag, flame impingement and erosion by the moving fuel bed.

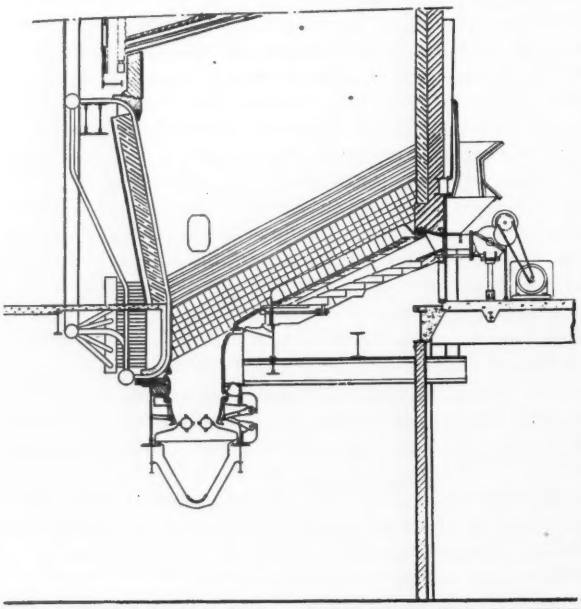


FIG. 1. BARE TUBES USED ABOVE FUEL BED TO STOP SLAG ON SIDE WALLS

Water-cooling, first applied to rear walls, has been extended to cover side walls and in some cases front walls, advantages being more pronounced as size, especially length of the stoker, is increased, with reduced clinkering and slagging and ability to use highly preheated air, hence less excess air without high cost of wall maintenance.

Bare Tubes for Slag Trap

For low grade coals high in sulphur and iron and for severe operating conditions, experience has shown that slag will run down and cover the face of the water-cooled section above the grates which is lined with refractory. This difficulty is marked where the ash is of low fusion temperature, say 2000 deg. F., and, to overcome it, bare tubes are used above the block-covered, water-cooled section and beyond the face of the refractory wall, a patented construction, which cools the slag and stops its flow onto the block-covered section. The construction and effect are shown in Figs. 1 and 2.

Capacity Is Increased

Additional capacity has been secured in old plants by the use of rear and side water walls to permit extension of a longer stoker under the bottom boiler drum as in Fig. 3, which increased output 60,000 lb. of steam an hour at an installation cost of $1.30 a pound; also as in Fig. 1 by permitting a higher combustion rate, which increased output 50,000 lb. an hour at an installation cost of 82 cents a pound, no change being made in the stoker.

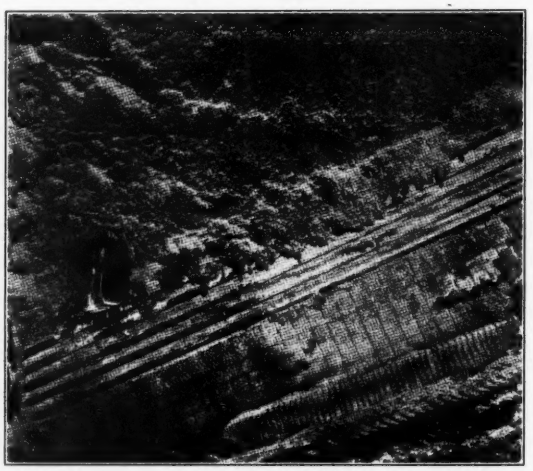


FIG. 2. EFFECT OF BARE TUBES ABOVE FUEL BED

Use of Lining Blocks

By using cast-iron or refractory-surfaced blocks on the water walls, W. R. Little stated that the rate of heat transfer can be controlled to give any furnace temperature desired and J. B. Crane told of successful use of water-cooled walls to enclose completely furnaces for blast-furnace gas, where it was long claimed refractory walls were essential to provide ignition tempera-

*From Proceedings, Engineers Society of Western Pennsylvania, May, 1931, p. 257.

**American Engineering Co.

ture. Figures on maintenance show 4 or 5 yr. operation, with no repairs in some cases, in others one or two tubes replaced in the walls.

For stokers, however, a water-coooled front wall may have detrimental effect on combustion adjacent to it, hence R. A. Foresman stated the Westinghouse practice to be 3 ft. of refractory wall above the stoker throat. Mr. Oberholtzer, however, cited a number of completely water-cooled stokered furnaces which have shown no harmful effect on combustion.

Operating Experiences

As to actual experience with water walls, T. E. Purcell stated that even with four water walls and latest practice in pulverized coal burners, the furnace temperature was so high that ash fusing at 2300 deg. F. slagged on the tubes when operating at high capacity, heat release of 30,000 B.t.u. per hr. per cu. ft. Slag

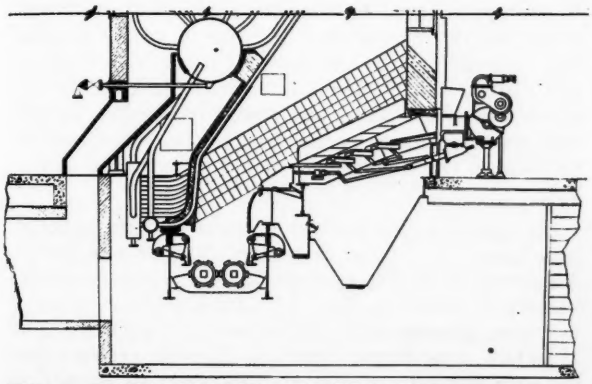


FIG. 3. WATER-COOLING ALLOWED USE OF LARGER STOKER EXTENDED UNDER BOTTOM DRUM

screening relieved this somewhat but not enough to remove it as a limit to continuous operation with low excess air at high capacity.

For stoker furnaces, as linings in the upper part are subject to less severe conditions than those in pulverized coal furnaces and as radiating surface of the fuel bed is small in proportion to total furnace boundary, less absorption of radiant heat is allowable, if temperature is to be held above the point which aids combustion. This and the cost difference has led to more reluctant use of water cooling in those zones not subject to the most severe service.

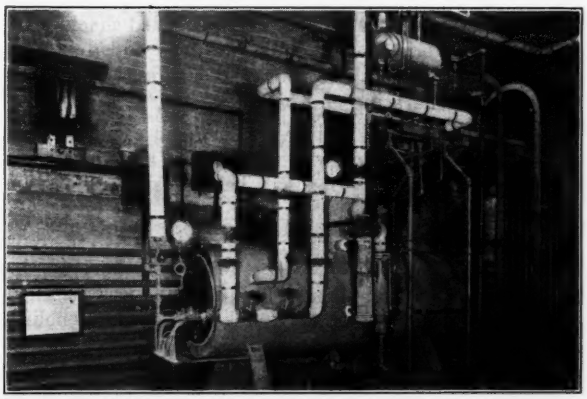
Trial of water tubes 6 in. inside the refractory walls at Allegheny County Steam Heating Co., intended to cool the floating ash particles, proved undesirable and the tubes were moved back against the face of the wall. Tubes recessed in the wall, having surfaces flush with the refractory, gave good results and were later used in some parts of furnaces at James H. Reed station. Facing the front, rear and side walls with refractory at Colfax to secure good combustion conditions resulted, at high capacity and low excess air, in severe slagging of walls and of tubes in the first pass. Some refractory blocks were replaced with metal blocks, others removed, so that the only refractory surface remaining is in the front wall above the burners. Combustion has not been affected, within the operating range of the boilers.

While water and steam-cooled walls add materially to capacity, D. D. Pendleton pointed out that when operating at high capacity, exit gas temperature is so high that heat recovery by economizers and air preheaters is usually necessary to get high plant efficiency. Various arrangements were shown of air preheaters with and without economizers, for pulverized coal, for gas and for stoker firing.

Mr. Oberholtzer stated that the bare blocks permit operation with higher CO_2 and temperatures than refractory blocks hence should give higher efficiency in stoker furnaces. Such furnaces, however, require less water-cooling than powdered coal practice.

Application of Steam Generator

Interesting application of the electric steam generator is shown by the accompanying illustration. The Research Department of the Celluloid Corp. was faced with the necessity of obtaining steam at 200 lb. pressure to be used in an atmosphere which might become explosive. The General Electric Co. suggested the use of an electric steam generator, pointing out that this installation would save the cost of a new building which otherwise must be built remote from the laboratory so that a fuel fire could be used safely. The use of the



ELECTRIC STEAM GENERATOR MAKES 200-LB. STEAM FOR LABORATORY

electric steam generator made the employment of a licensed engineer unnecessary and made it possible to generate steam safely in the laboratory itself.

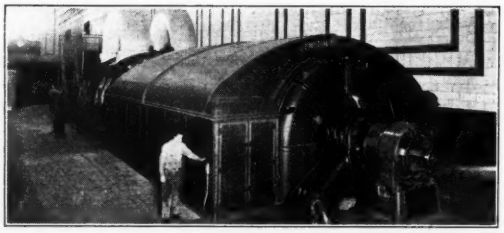
Accessory equipment includes an automatic pressure governor, an automatic heat shutoff and a low water alarm whistle. Great care has been taken in the design of the equipment to minimize danger in its operation. For example, the magnetic switch operates in oil, the pressure governor is enclosed in a gas-tight case and the automatic heat shutoff switch operates inside of the generator under 200 lb. pressure.

Osage 200,000 Hp. Project Nears Completion

In the article under the above title on page 763 of the July 15 issue credit should have been given to Stone & Webster Engineering Corp. as designers and builders of the power plant and dam and the transmission line.

THE POWER BEHIND NEW YORK

Part IV. Final considerations. The design and development of East River Station.



HAVING CONSIDERED the development of Hell Gate and Hudson Avenue Stations, we come now to the latest of all the New York Stations, East River Station of the New York Edison Co.

East River Station was placed in operation in November, 1926. At the time it was designed, Manhattan Island was served almost exclusively from the 25-cycle system with conversion to direct current, and East River Station was planned to be a 25-cycle station. The initial installation consisted of two 60,000-kw. generating units, the first going into operation on November 19, 1926, and the second on February 21, 1927. A third machine, a 160,000-kw. tandem compound unit was added in October, 1929. These three 25-cycle machines constitute the present generating equipment.

Under the present policy, as has been explained, no additional 25-cycle units will be installed and the future development of the station will be exclusively along 60 cycle lines.

In addition to this generating equipment, there is also provided a 40,000-kw. frequency changer, of the synchronous-induction type. This machine was installed for a twofold purpose: first, to make possible the pooling of the spare capacity on the 60-cycle and 25-cycle systems; second, to maintain the two systems in synchronism.

At the time the frequency changer was installed, the rotary converters supplying the d.c. network were all 25-cycle machines but it was thought that in view of the pronounced trend toward 60 cycles as a standard frequency, it might be desirable in future installations to use 60-cycle converters. In order to obtain satisfactory operation of the two types of rotary converters, it was realized that it would be essential to keep the two systems in synchronism and that, furthermore, to prevent possible damage to the commutation equipment the tie between the two systems should be as strong as possible.

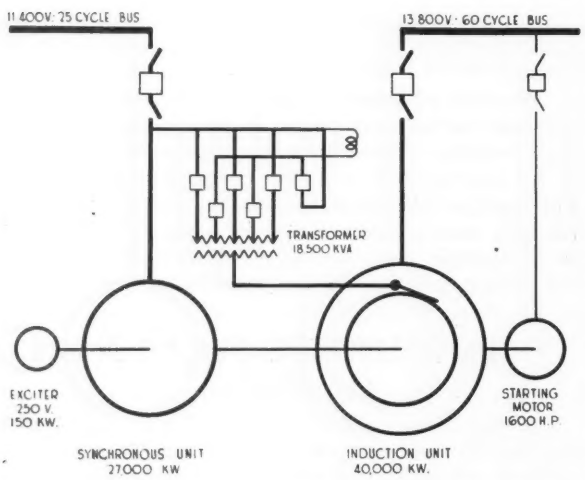


FIG. 1. ELECTRICAL CONNECTIONS OF FREQUENCY CHANGER AT EAST RIVER

It was with this thought in mind that the synchronous induction type of frequency changer was chosen. A diagram of the electrical connections of this frequency changer is shown in Fig. 1. The 40,000-kw., 60-cycle induction generator, it will be noted, is excited by an 18,500-kw. transformer from the 25-cycle system; thus the arrangement provides a transformer tie as well as a power tie.

While the installation of the first 160,000-kw. single shaft generator at East River was a notable achievement in the power world, it is in the boiler room that this station differs most from the other stations, for this is the only all-pulverized fuel burning plant on the system.

The central system of pulverizing is employed, all pulverizing and coal preparations being installed in a separate building across the street from the station proper. The pulverizing equipment consists of two 15-t. and four 25-t. Raymond air swept mills, the drying being accomplished by air drawn by steam air heaters. The temperature of the coal leaving the mills does not exceed 105 deg. F. After leaving the mills, the coal is conveyed by means of transport pumps to the boiler room coal bins.

The initial boiler installation consisted of six 14,809-sq. ft. Springfield horizontal cross drum boilers, with 4134 sq. ft. of water wall surface on all four sides of the furnace and a slag screen above the ash pit. The superheater on these units contains 3430 sq. ft. of heating surface and is of the hairpin type, while the air preheater contains 28,900 sq. ft. of surface. The Lapulco system of vertical firing with ten main burners and ten auxiliary burners is used.

These boilers were provided for the first two 60,000-kw. generating units. For the 160,000-kw. machine, three additional boilers were provided in 1929. These are 800,000-lb. per hr. units of the Ladd type fired from both ends. Each boiler contains 60,706 sq. ft. of heating

surface and 7345 sq. ft. of water wall surface on all four sides of the furnace with a slag screen above the furnace. The superheater contains 13,900 sq. ft. of heating surface and is of the hairpin type, while the plate type air preheater contains 82,721 sq. ft. of effective heating surface. The furnace has a volume of 38,200 cu. ft. with a heat liberation of 29,300 B.t.u. per cu. ft. of furnace volume when operating at 800,000 lb. of steam per hr. Steam conditions are 425 lb. gage pressure with 725 deg. total temperature. Each unit is fired by 20 main burners and 20 auxiliary burners, 10 of each on each side.

These boilers when installed were the largest steam generating units ever built and today have not been exceeded. While the maximum guaranteed capacities were 800,000 lb. of steam per hour, it was felt by the designers that this estimate was conservative. That these conclusions were well founded is proved by their subsequent performance, for they have produced as high as 1,250,000 lb. of steam per hour. This performance is all the more remarkable when it is considered that the space in which this unit is installed was originally designed for two boilers, each having a maximum output of 250,000 lb. of steam per hour.

In selecting pulverized fuel for East River Station, several factors entered into the decision:

1. It was believed that this type of firing would permit a much larger field from which to purchase suitable coal and that high efficiencies could be maintained with some of the cheaper grades of coal which can be burned only with great difficulty on stokers.

2. It was felt that the time of boiler outage would be less with pulverized coal than with stokers.

3. The experience of others in burning pulverized coal indicated a much flatter efficiency curve than with stoker firing.

Considerable difficulty was experienced in the early stages of the station's operation in maintaining stable firing condition with the vertical burner system originally installed. After experimenting in various ways, A. J. Wheeler, Jr., superintendent of the station, conceived and developed the idea that by applying a flame to the stream of coal immediately after its entrance to the furnace, combustion could be accelerated to a point where the heat radiated from the flame to the water cooled walls did not reduce the flame temperature to a point where combustion was retarded. Applying this principle, small auxiliary burners have been installed at right angles to each vertical burner, so disposed as to impinge on the stream of fuel leaving the vertical burner at a point slightly below its entrance into the furnace.

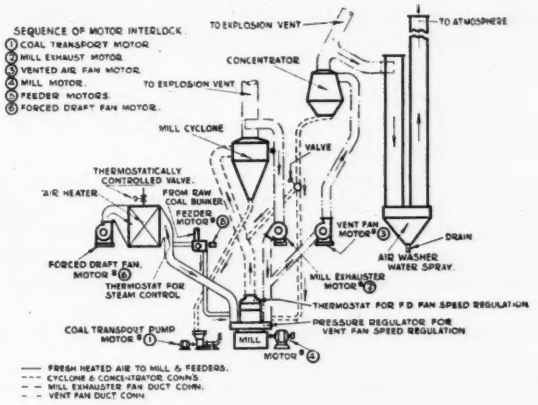


FIG. 2. PULVERIZING EQUIPMENT FOR A 25-T. MILL AT EAST RIVER

Because of the location of East River Station in the heart of New York, every effort had to be made to prevent the spread of dust and fly ash from the stacks. To effect this two types of dust catchers are in use: cyclone separators and electrostatic precipitators. A Davidson cyclone separator was installed on each of the first six boilers with satisfying results.

The three new boilers are provided with Cottrell precipitators. These precipitators consist of a steel shell containing concrete slabs, 2 in. thick, placed 8 in. apart, through which the gas passes. In the slabs are steel rods which act as positive electrodes. Centrally in the gas passages and electrically insulated are hung wires, which are given a high potential negative charge. The electrical field between the positive and negative elec-

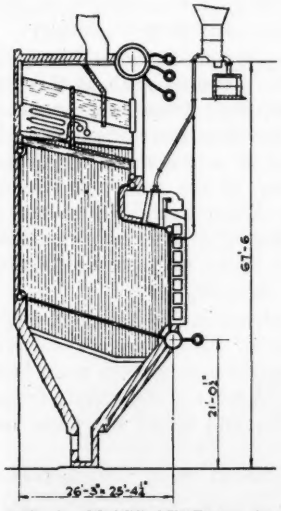


FIG. 3. CROSS SECTION OLD BOILER UNITS AT EAST RIVER

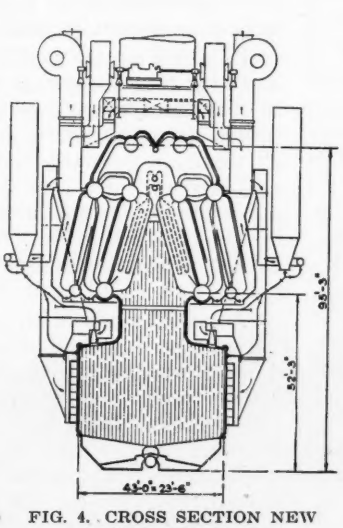


FIG. 4. CROSS SECTION NEW BOILER UNITS AT EAST RIVER

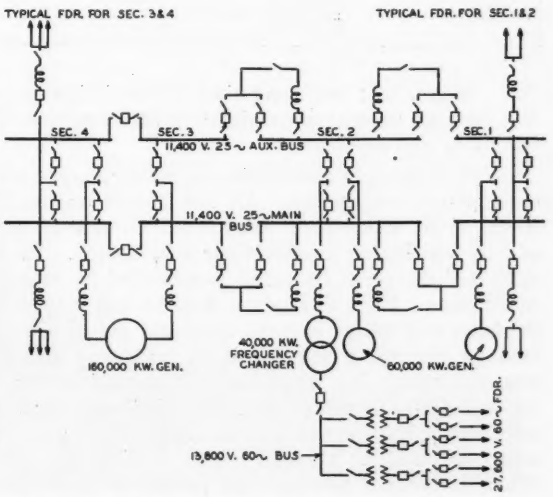


FIG. 5. BUS ARRANGEMENT AT EAST RIVER STATION

trodes repels the dust particles against the concrete slabs from which it is scraped periodically into a collecting hopper.

These precipitators have given excellent service, tests indicating a removal of from 90 to 95 per cent of the solid matter in the gases.

From the foregoing discussion of these three major stations of the New York Edison System, it will be evident that though they serve the same system and operate as a unit, each represents a different line of engineering thought which is reflected in differences in their design. At the same time, their design is such that they all present approximately the same degree of reliability and economy.

PRINCIPAL EQUIPMENT INSTALLED AT EAST RIVER

Unit No.	1 & 2	4
Turbo-Generator		
Make	G. E. Co.	G. E. Co.
Type	Single Cyl.	Tandem Comp.
Rating	60,000	160,000
Cycles	25	25
R.P.M.	1500	1500
Condenser		
Make	Wheeler single pass	Ingersoll-Rand single pass
Area	45,000	90,000
Circulators		
Number	1	1
Cap. g.p.m. each	45,000	80,000
Hotwell pumps	2	3
Steam ejectors	1	12 primary - 4 secondary
Boiler Feed Pumps		
Make	Dean Hill	Dean Hill
Number per unit	2	3
Head lb. per sq. in.	500	630
Cap. g.p.m.	1200	2000
Boilers		
Number	3	3
Make	Springfield	Comb. Eng. Co.
Type	Cross drum	Double Ladd
Heating Surface		
Boiler	14,809	60,706
Water Walls	4134	7545
Superheater	3430	13,900
Air Preheaters		
Make	C. E. Corp.	C. E. Corp.
Type	Steel plate	Steel plate
Area sq. ft.	28,900	82,721
Combustion Equipment		
Make of system	C. E. Co.	C. E. Co.
Type	Central	Central
Type mills	Raymond	Raymond
Type burners	Vertical	Vertical
No.burners per boiler	10 main - 10 aux.	20 main - 20 aux.
Furnace Vol.	15,888	38,200
Forced Draft Fans		
Number per boiler	1	2
Make	Sturtevant	Sturtevant
Static head, in.	6.4	9
Cap.cu.ft. per min.	60,000	125,000
Induced Draft Fans		
Number per boiler	1	2
Make	Sturtevant	Sturtevant
Static head, in.	8.5	17
Cap.cu.ft. per min.	150,000	260,000
Primary Air Fans		
Number	5 for 6 boilers	4 for 3 boilers
Make	Sturtevant	Sturtevant
Capacity	2400 cu.ft. at 40 in. static head	54,000 cu.ft. at 25 in. static head

With respect to their coal and water supply, all of these plants are similar. All are located on the East River, from which they draw their circulating water and by which they receive their coal supply. In each case, coal delivered by barge is unloaded by means of coal towers. Both at Hudson Avenue and East River, the hoist and trolley motors in the coal towers are operated on direct current furnished by motor generator sets and using the Ward-Leonard method of control. At Hell Gate, however, until the third coal tower was provided in 1929, variable speed alternating current motors were used on the two towers serving the station. When it became necessary to provide a third tower, however, studies were made as to the operating and maintenance of the coal towers in the other stations and because of the fact that the Ward-Leonard system showed the lowest maintenance costs, this system of control was selected for the third tower.

In regard to the control of the boiler equipment, it is of interest to know that the Smoot automatic combustion control system is used in all stations. In this system, the desired steam pressure is set on a super-master panel and any change in this pressure, due to changing loads on the turbines, will immediately affect the speed of stokers or coal feeders, and fans, thus bringing the pressure back to the desired point.

The auxiliary electrical supply in these three stations varies considerably. At Hell Gate, the auxiliaries with the exception of several of the boiler feed pumps, high pressure drip, fire pumps and standby exciters, are supplied from either a transformer or house generator bus. Reliability of operation is obtained by the duplication of all major condenser auxiliaries and their proper proportioning between the transformer and house generator buses.

At Hudson Avenue, the power for the main auxiliaries for each group of two generators is derived from three sources: one transformer bank fed from the main station bus, one 25 to 60-cycle, 6600 to 2300-v. frequency changer fed from the 25-cycle Gold Street Station and from a house turbine. Normally, all 2300-v. auxiliaries are operated from the house transformers with the house turbine and the frequency changer floating as synchronous condensers. This applies primarily to the first half of the station. With the addition of the second half of the station, some modification in the auxiliary supply scheme as already described.

At East River, the auxiliary supply scheme is somewhat different. There, the nonessential auxiliaries (those which may be shut down for short periods) are supplied from 2300-v. or 440-v., 25-cycle buses energized from house transformers on the main bus. These house buses also supply motors for ventilating fans for the main generators and frequency changers. The transformers supplying these buses are supplied from different sections of the main bus.

A 125/250-v. d.c. house bus supplied from geared cross connected turbo-generator units is provided for the operation of boiler fuel feed. As a standby to the turbo-generator units there is a 2240-amp-hr. battery.

In laying out the auxiliary system for East River, it was clear that the system for a station such as this to be satisfactory should be supplied from such sources that in case of a break in any steam line, a shutdown of all the main generator units, a shutdown of any one auxiliary unit or a shut down of the main bus would not interrupt the operation of the auxiliaries to more than one generating unit. Naturally, these requirements do not necessarily apply to other projects or to the present day conditions in the territory served.

A careful study of all systems in use indicated that the requirements could be met by the following systems: A, steam turbines; B, d.c. electric supply from main bus with storage battery reserve; C, a.c. electric supply from half alternators with main bus and house alternator in reserve.

Estimates made on the basis of these various plans showed that the a.c. electric system would cost 35 per cent more than steam turbines and the d.c. system 120 per cent more than steam turbines. It was because of

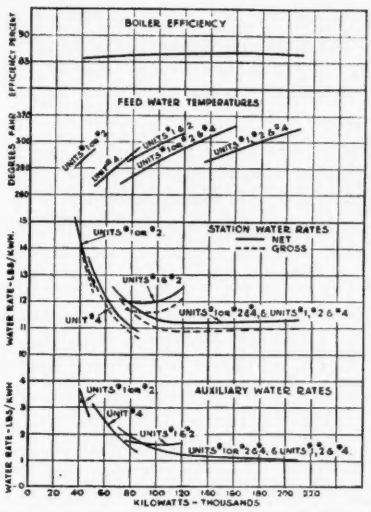


FIG. 6. EAST RIVER STATION PERFORMANCE DATA

the results of these studies that the steam drive was selected.

Electrical Features

On the electrical side, these three stations differ considerably in regard to details of construction and arrangement, but they all incorporate certain general principles in common. Thus, all stations in the vertical isolated phase bus arrangement and the same general arrangement of switching apparatus. The generating equipment is similar except that each succeeding machine incorporates in it the new features available at the time of its installation. This, of course, is true, more or less, of all other equipment.

A feature of particular interest is the double winding arrangement used on the 160,000-kw. generator at East River.

Due to the high current of a unit of this size it was impossible to procure single generator switches of sufficient carrying capacity. It was necessary, therefore, to consider two switches in parallel. The use of a double winding generator, however, provided a simple means of assuring satisfactory load division between the output circuits and at the same time reduced the current capacity and interrupting duty on the switches.

The new 160,000-kw. machines for Hudson Avenue will also be of this double winding type. The 160,000-kw. units at Hell Gate are different, however, for these are cross compound units with two separate generators which gives virtually the same net results as the double winding generators.

Conclusion

With this brief summary, we will conclude this description of the New York Edison System. It is realized that in a series of articles of this length only the most important aspects of a system of this magnitude can be touched upon and no attempt at detailed descriptions can be made. Our purpose, here, has been to present a comprehensive picture of the system as a whole, its purpose, its history and its present development. The system, as has been shown, has many features of engineering interest, but even if there were no other elements of interest, the element of size alone would make the system of interest; for it must be remembered that the population of New York City is almost as great as that of the State of Ohio, which is the fourth most populous state in the Union. The population of Brooklyn alone is over 2,000,000.

Yet all this enormous population is served by only seven generating stations. The size of the system itself would introduce problems but when the congested condition of the community is considered and the high cost of real estate, it is evident that a system of this kind will be subject to many problems not found in smaller systems.

It is evident also that the problems encountered in the operation of a system of this type are not such as may be solved once and for all and then forgotten. New problems are constantly arising and these new problems often are such that their solution can be effected only through study and analysis of past performance and existing conditions. To this end, the executives and engineers responsible for the operation of the system must be eternally "on the job." And to them goes the credit and praise for the excellence of the system they represent and its fine service to the community in which they live. It is true perhaps that many of the developments in this system have been literally forced upon these engineers—they have been the result of solving problems which perforce must be solved, and at once. But the boldness of conception, the shrewd analytical foresight, the sound economic judgment with which such problems have been handled not alone by the engineers of the New York Edison system but by engineers in general throughout the country are deserving of the highest praise.

In closing, we wish to acknowledge our indebtedness to the executives and engineers of the respective companies comprising the New York Edison System for many courtesies extended and for the information used as the basis of these articles.

Keep Diesel Pistons Tight to Prevent Explosions

LEAKY PISTON RINGS MAY REDUCE COMPRESSION, PREVENT FIRING, CAUSE OIL ACCUMULATION AND LEAD TO AN EXPLOSION. BY ORVILLE ADAMS

ENGINE EXPLOSIONS not only may cause damage expensive to repair; the most serious consequence is in endangering the lives of the operators. Although the Diesel industry is comparatively young there have not been many serious accidents of a nature to cause a great deal of human suffering as well as serious dents in the engine owner's pocket book. There have been sufficient, however, to warrant a study of the various causes.

It is possible that the cause of numerous accidents is leaky piston rings, causing reduced compression. The remedies available should be used in all cases not only for the sake of economy but to safeguard the operators.

In cases analyzed, there was a history of leaks in the combustion chamber, caused by valves, rings, gaskets and the like, which lowered the compression to a point where the injected fuel did not fire but accumulated. After a few dozen strokes, with the governor increasing the injection volume to hold the speed and more fuel going into the cylinder each time, enough compression was generated to cause the cylinder which had cut out to start firing again. While the cylinder was missing, fuel accumulated but, without the firing pressure, the cylinder that already had leaky rings began to pump oil. When this accumulated around the top rings in large amounts, it tended to overcome for the moment the mechanical deficiencies of wear and effectively sealed the piston, this provided the normal compression, resulting in ignition. With all the surplus fuel firing at once, explosions usually resulted, since the fuel is already in the cylinder before the firing time. Heads might blow off; the piston and connecting rod might be blown down into the crank case.

The obvious remedy is to keep the compression normal and high enough to insure sufficient heat to ignite the fuel at every stroke. Missing cylinders on a Diesel engine are dangerous cylinders. Common experience with explosions in the muffler of an automobile illustrate the possibilities in this. Valve grinding, replacement of rings and reboring of tapered cylinders are remedies.

Badly-tapered cylinders make ring fitting almost impossible. Two-piece rings are safe and economical as a remedy at certain stages of the engine life, after much wear has taken place and up to the obvious time for reboring. It is generally good practice to rebore after 0.005 in wear per inch of piston diameter. Few types of ring should be depended upon after this amount of wear has occurred in the cylinder bore, for it is usually accompanied by wear in the ring grooves and the rings cannot be fitted with proper clearance in the taper for they will be too tight in the lower part of the cylinder. Stuck rings, moreover, are often experienced with worn engines. One of the apparent reasons for so many rings in some Diesel cylinders is to make sure they will not all stick and leave the cylinder without compression.

With half of the rings stuck, in a worn cylinder, it is frequently impossible to secure sufficient compression. The writer has seen engines so badly worn that starting was almost impossible without use of punk sticks, torches, or pouring graphite and lubricating oil into the cylinder prior to starting. An engine in this condition is decidedly dangerous as a source of explosions in the cylinder. Assuming that the injection system is not at fault, a hard starting engine should not be operated long after the difficulty shows up for it is a sign that reboring is needed.

One of the principal virtues of the cold starting oil engine, operating with higher compression than would otherwise be necessary compared with the same engine operating as a semi-Diesel is the very fact that it may refuse to start sometime before it reaches the danger point of explosions due to the conditions pointed out above. It quits before it gets dangerous. When an operator, however, must resort continually to graphite and torches to start his engine, that engine is already too dangerous for any one who knows of the possibilities of explosions.

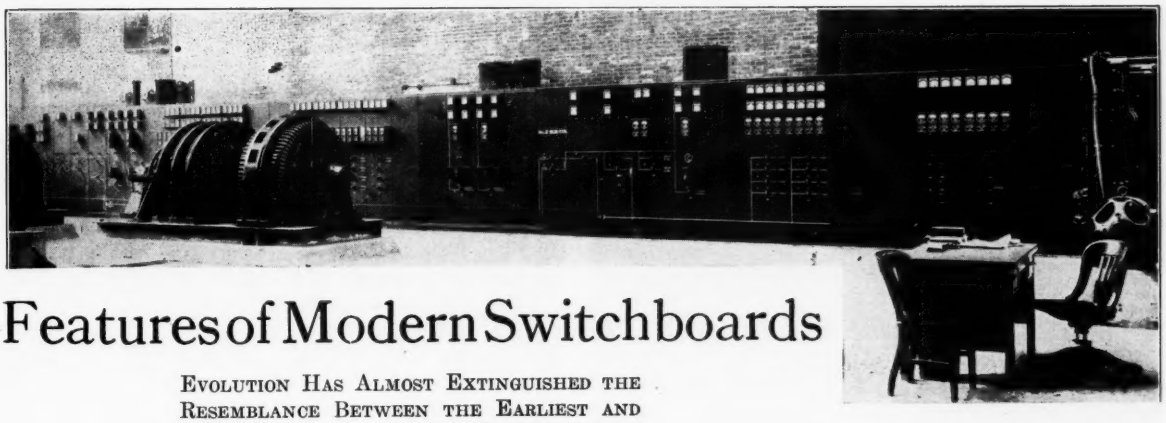
Many engines are fitted with two-piece sealing rings from the outset, a greater number of rings are provided than necessary, and it is operated on as low compression as possible to start cold in ordinary weather. This type of engine is not so dangerous as the cold starter which has extra high compression and is equipped with plain snap rings whose gaps open up in the upper bore after wear occurs.

A Diesel without sufficient compression for any reason should be feared by operators and owners should not neglect to recondition for natural wear to a danger point. Compression indicators should become more common in oil engine plants for these many reasons and renewing the rings cannot be too strongly advocated, as well as pulling pistons frequently when sticking rings are known to be in the engine.

Michigan Limestone & Chemical Co. Builds 16,000 Kw. Power Plant

IN THE DESCRIPTION of the new power plant of the Michigan Limestone & Chemical Co. under the above title in the July 15, 1931, issue of Power Plant Engineering, an error appears in the 6th paragraph of the left hand column of page 739. The text states that "Duplicate condensate pumps, 270 g.p.m. each against 114 ft. head, send water from the condenser hotwell through generator air cooler to two extraction feedwater heaters." This sentence should read instead that the condensate pumps "send water from the condenser hotwell through the inter and after condenser of the steam jet air pump to two extraction feedwater heaters." The correct flow of condensate is shown in Fig. 4 of page 741. According to the designing engineers, it has generally been found uneconomical to use the condensate through the generator air cooler unless the circulating water is extremely foul, because if this is done it is necessary to have an auxiliary air cooler installed in connection with the condensate cooler for light load operation.

THE VOLUME of a pound of air at 32 deg. F. and one standard atmosphere is 12.39 cu. ft.



Features of Modern Switchboards

EVOLUTION HAS ALMOST EXTINGUISHED THE RESEMBLANCE BETWEEN THE EARLIEST AND LATEST SWITCHBOARDS. BY EMIL G. BERN*

WHEN THE SO-CALLED "grape arbor" type of switchboard illustrated in Fig. 1 came into being in the first spring days of the electrical industry, the usual complacent satisfaction lingered for a moment until progress made new demands. Electric power was a reality—no longer a dream. This power could be controlled from central points, not by heavy levers of grimy steel but by the touch of a switch. The grape arbor board was the primitive support for a collection of these switches and for the gages or instruments which were to show the behavior of this new servant of industry. These switchboards were made—not designed and manufactured. There was yet no thought of building them into self-contained apparatus, protected against vermin, against the accidental dropping of a tool, or against the spreading of trouble in case of individual distress on any one circuit. The safety-first slogan was not yet heard in the clanging world of our industrial wheels.

Increased efficiency, expressed also in simpler maintenance work, smaller space, lower cost, were the new demands made by progress. Finally, when it was pointed out that the esthetic feature usually goes hand-in-hand, inseparably with economic design, the question of appearance began to find its proper place. The industrial switchboard of today is a substantial structure that generally embodies these features.

UNIT PRINCIPLE OF DESIGN

Compactness is demanded; perhaps not always because of space limitations, but because of preparedness for extensions and changes which new manufacturing processes and methods may bring out any day in the uncertain future, and which usually mean changes in electric power distribution with corresponding changes in switching equipment. A unit principle, as far as it can be feasibly extended to switchgear, offers an ideal construction for installation, with the highest salvage value in case of revamping or relocating the equipment.

In the industrial plant it often becomes necessary to move equipments from one location to another. Compactness is then a valuable factor. The switchboard material may be either metal or insulation panels. Figure 2 and Fig. 3 show an economically designed industrial switchboard of insulation panels with 6 in. circuit spacing. Except for miniature boards where a "finger-tip" control is desired, the 6 or 8-in. circuit spacing is the most feasible for electrical control and metering equipment.

Accessibility is of utmost importance where continuity of service is prized. Nevertheless, it is usually required that connections and live parts be enclosed or suitably protected; therefore, the ideal switchboard is so designed that the authorized key gives access to the entire equipment for inspection or trouble-hunting without the need of wrenches or screw drivers. With the ordinary switchboard of insulation panels, this is usually accomplished by the installation of a grille enclosure back of the board. With the duplex unit switchboard, Fig. 4, the hinged panels on the rear side of the structure provide access to the interior of the particular unit which it is desired to inspect. These hinged panels also serve to support relays, meters and other general equipment not of primary concern to the operator. In this manner the duplex unit switchboard

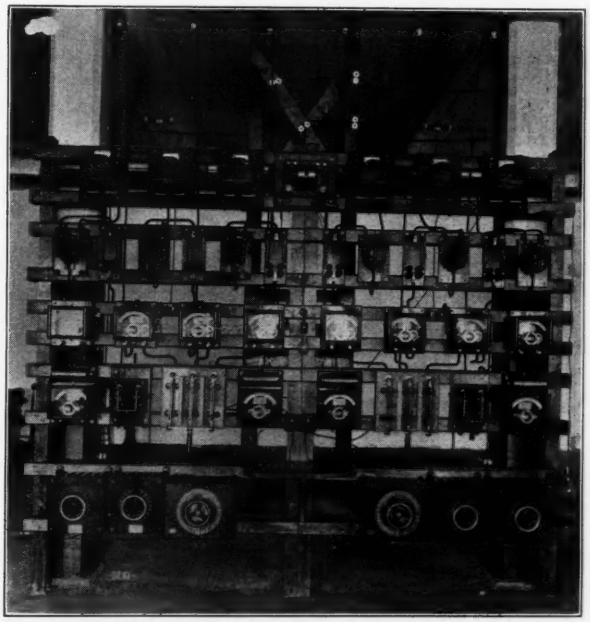


FIG. 1. GRAPE ARBOR TYPE OF EARLY SWITCHBOARD

*General Electric Co., Philadelphia, Pa.

FIG. 2. COMPACT—BUT NOT CROWDED—EVERYTHING ACCESSIBLE FRONT AND BACK

offers an unusual space economy. This construction can of course be built with panels of insulation material, although the metal construction is slightly more economical in space.

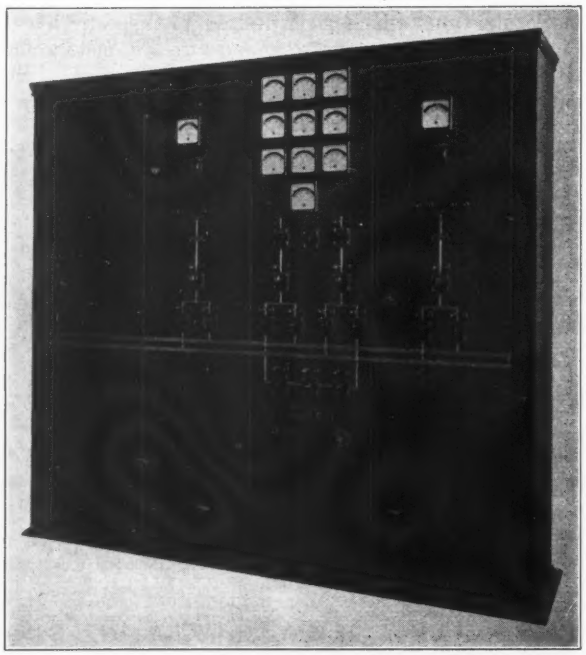


FIG. 4. DUPLEX UNIT SWITCHBOARD OF STEEL. SELF SUPPORTING, WITH HINGED REAR PANELS FOR ACCESS TO WIRING AND FOR MOUNTING OF AUXILIARY EQUIPMENT. FOUR VERTICAL ROWS OF INSTRUMENTS, METERS, RELAYS AND CALIBRATING EQUIPMENT CAN BE ACCOMMODATED ON EACH 24-IN. PANEL

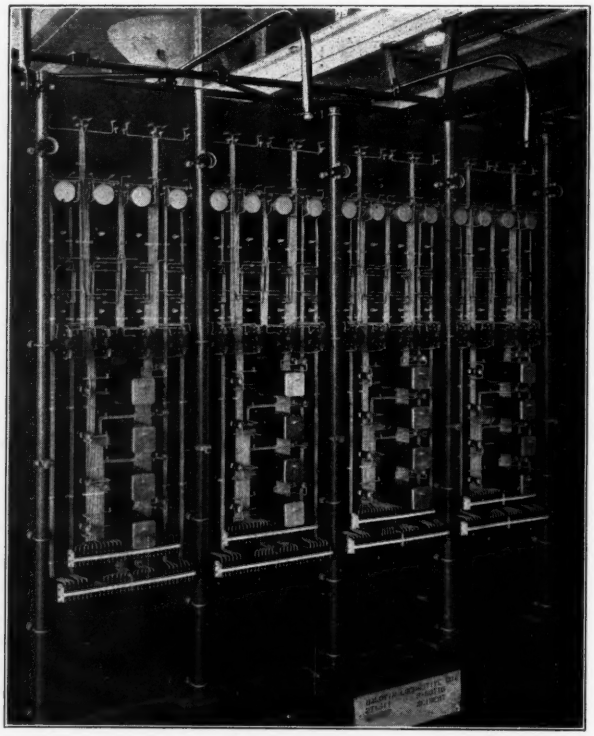


FIG. 3. CONTROL AND INSTRUMENT CONNECTIONS BACK OF INDUSTRIAL SWITCHBOARD SHOWN IN FIG. 2

Orderly arrangement of details is an inspiration towards care and orderliness wherever it is found. An orderly arrangement of the connections back of a switchboard helps in locating trouble quickly under emergency conditions. It inspires the maintenance man to uphold a quality of workmanship that is the best insurance against accidents and troubles in the future. An orderly, cleated wiring is an important feature with any industrial switchboard and this feature has received an almost universal approval and appreciation during the last few years.

Harmony in Design of Devices

Neat appearance, as already stated, has been found to go hand in hand with good and economical construction. Switchboard design also involves the design of individual devices as well as the structural and electrical planning of the whole equipment. Unfortunately, this condition has not been given its full measure of consideration. Obviously, it would be impossible to obtain the best results by distributing the design work of a machine among a dozen different designers without any means of coöperation. Each individual part might turn out to be a perfect piece of work: admirably proportioned when considered as a unit. At the same time the different parts or units might be so inconsistent among themselves that the result of the whole machine might be considered a failure.

This very thing has long been recognized as one of the most fundamental factors in switchgear design. Coördination in appearance as well as in operating characteristics has been a difficult goal to attain, but has had to be achieved in order to produce the best results. It has been necessary to take into account not

only the relative amount of space that could be allotted to different devices, such as instruments, meters, relays, recording instruments, control and testing equipment, to obtain the best overall result and at the same time the ideal operation of each component part; but it has also been necessary to design these different devices for the best overall result.

Manufacturers of modern switchboards have taken into account appearance and consistency in design as well as space economy and other requirements. Perhaps the illustration at the head of this article will give an idea of what can be done in the design of an industrial switchboard under these conditions. While space has been amply provided for almost any future contingency, the completely equipped units leave little further to be desired in compactness and appearance. This particular installation was reduced to 77 per cent of the original length by the introduction of a design built on 6-in. circuit centers. Mimic connections to help visualize the main connections are produced in colored lacquer directly on the face of the switchboard, which gives a durable and simple construction. Simplicity is after all the keynote in a compact, orderly and neat design.

It Pays to Know Your Lamp Life*

SYSTEMATIC STUDIES OF LAMP OPERATION AND PROPER METHODS OF RECORDING DATA RESULT IN SUBSTANTIAL SAVINGS. BY LESLIE B. GORDON†

LAMP LIFE IN OUR PLANT for the past eight years is a matter of history. To explain just how we have arrived at a definite average figure, some of our experience will be related.

To try to obtain a fairly definite figure on average daily burning lamp-hours, we at first detailed one man to check lamps, that is, to check in each of the various departments the number of hours the lamps burned. This necessitated that this particular man visit the departments as often as possible during his working day. Over a period of six months, considerable data was obtained but, because of the cost of gathering this information, another scheme was decided on which worked out more accurately and with a much smaller cost.

We placed a Portable Tagliabue Recording Thermometer in this service, leaving it in each of the departments and at various spots, until the desired information was obtained, when it was moved to another department. Several months were required to gather this data throughout the plant. The bulb of the recorder was placed as near the lamp as possible so that the fluctuations due to heat would be as nearly instantaneous as could be expected. With this scheme we were and are able to arrive at a very accurate average of burning lamp-hours per day. The sample chart, which is typical of the ones gathered throughout our plant, shows an approximate daily average of from 7 to 7.5 hr., the latter being the figure we use to compute total lamp life.

The question arises as to whether all this is not too expensive; whether it is worth the cost. The cost at first may seem somewhat out of line; however, the benefits amply compensate for the investment. It may also be suggested that this would be a good investment only in a large plant. The first cost may be rather high in a smaller plant but if properly followed up, it will pay. With our company, this is history—an operating fact.

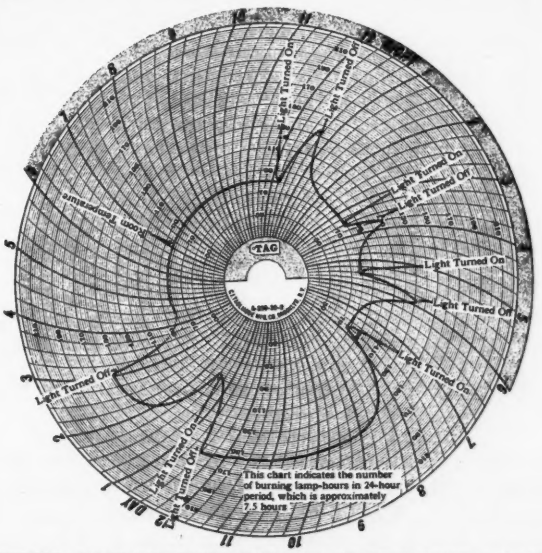
Throughout our plant, we have approximately 6500 outlets for lamps. One man is detailed to look after all lamps as well as keep his daily records; these records are brought up to date each month by a statistician in the engineering department and summarized each year from the daily and monthly records.

*Abstract of an article appearing in the July issue of the Electric Journal.

†Electrical and Assistant Plant Engineer, Kelly-Springfield Tire Co.

MARKING LAMPS

Originally a small sticker was placed on each lamp. When the lamp is placed in service, the date put in service is filled in; and when it is taken out of service,


Light Turned On
Light Turned Off
This chart indicates the number of burning lamp-hours in 24-hour period, which is approximately 7.5 hours

TYPICAL THERMOMETER RECORD OF THE TIME A LAMP IS BURNED

the date taken out of service is filled in. In this way, it is easy to determine the number of days the lamps are in service, as well as the hours burned, using our daily average of 7.5 hr.

Occasionally, the paper sticker would become charred from the heat, even though the sticker was placed at the top of the neck of lamp as near the base as possible. We then found that by painting the glass near the base with a small amount of etching material, using a small brush, we had a better spot to place the date-in and date-out information which, made with a carbon pencil, would remain throughout the life of lamp. Carbon pencil marks are not affected by washing.

In keeping this check and record, we are able to find spots where we have short life due to vibration. When this condition is found, we try to eliminate it by placing a shock absorber fitting on the fixture, which usually

takes care of the trouble. We have placed several hundred of these shock absorbers in our plant, with a great improvement in lamp life.

After several years' experience, and with instructions from the lamp companies' engineers, we are now able to analyze our lamp troubles quite accurately. For example, we can tell whether a lamp has given short life due to vibration or mechanical shock by an examination of the filament; we can distinguish normal lamp failures by the degree and character of the bulb discoloration and can detect failures resulting from faults in our own installation, which we try to correct. From our records, we are able to determine whether we should receive credit on lamps which have not given proper life. Here is where part of the returns come back on the investment. When a plant engineer is able to show the proper records in connection with lamps, he is in a much better position to claim credits from the jobber or manufacturer's representative. This at least has been our experience. The principal returns have been from a greatly increased average life of lamp, due to checking the individual installations.

What the Records Show

Our records show that some of our lamps give two and three hundred per cent life, even more in some cases. If we knew when our lamps had given 100 per cent to 120 per cent hours-life, we would replace them, due to the fact that the efficiency and intensity drop off quite rapidly after the normal lamp life of 1000 hr. is reached. This plan could be worked out, but in this case it is a question as to whether or not the benefits derived would offset the cost.

Our costs for the maintenance of lamps as outlined, which includes records, etc., aside from compilation and summarizing, amounts to approximately 17 cents per outlet per year—less perhaps than under average normal maintenance conditions.

After operating this plan for a period of approximately 8 yr., we have been able to obtain credits on short-life lamps and along with this we have also increased our average lamp life about 100 per cent. This lamp life increase is, of course, due to rather intensive studies of all of our lighting and lamp problems. This proves conclusively that the method we use pays very good returns in our plant.

The mortality curves in Figs. 1 to 7 give a pretty clear picture of the performance of the various size lamps, as well as Fig. 8, which covers all lamps of all sizes. It might be well to mention the reason for the rapid drop of the curve in Fig. 2, which covers the 50-w. size. These lamps are used mostly in extensions and receive about the most severe service possible.

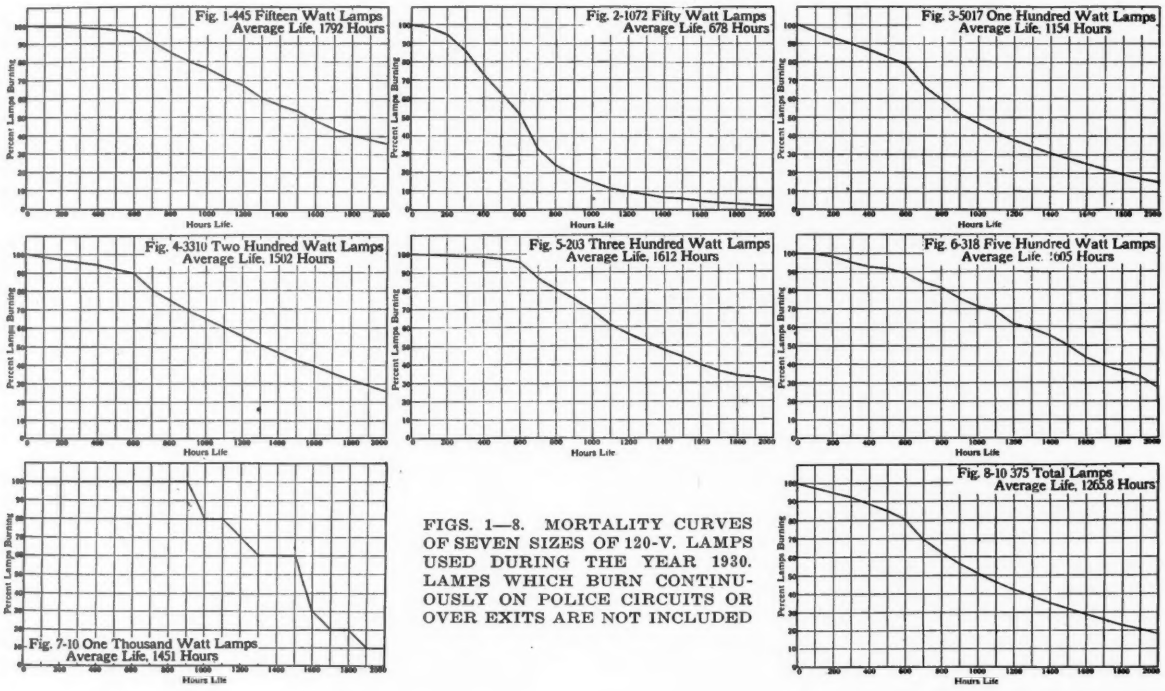


Fig. 1-445 Fifteen Watt Lamps Average Life, 1792 Hours
Fig. 2-1072 Fifty Watt Lamps Average Life, 678 Hours
Fig. 3-5017 One Hundred Watt Lamps Average Life, 1154 Hours
Fig. 4-3310 Two Hundred Watt Lamps Average Life, 1502 Hours
Fig. 5-203 Three Hundred Watt Lamps Average Life, 1612 Hours
Fig. 6-318 Five Hundred Watt Lamps Average Life, 1605 Hours
Fig. 7-10 One Thousand Watt Lamps Average Life, 1451 Hours
Fig. 8-10 375 Total Lamps Average Life, 12658 Hours
Percent Lamps Burning
Hours Life

FIGS. 1—8. MORTALITY CURVES OF SEVEN SIZES OF 120-V. LAMPS USED DURING THE YEAR 1930. LAMPS WHICH BURN CONTINUOUSLY ON POLICE CIRCUITS OR OVER EXITS ARE NOT INCLUDED

Reports of new orders for fabricated structural steel for the week ending July 18, 1931, were received by the Bureau of the Census from 104 establishments, whose capacity represented 54.3 per cent of the total capacity of all plants in the United States. The bookings reported by these establishments amounted to 24,069 t., representing 48 per cent of the total capacity of reporting establishments. Reports of shipments of fabricated structural steel for the same week were received from 100 establishments, whose capacity represented 52 per cent of the total capacity of all plants in the United States. The shipments reported by these establishments amounted to 24,362 t. representing 50.7 per cent of the total capacity of the reporting establishments.

Peat when dried runs about 35 per cent fixed carbon.

A Strenuous STEAM ENGINE Repair Job

Part I. In which a 3 or 4 day advisory job for a well known erection engineer, turns into 350 days hard labor reconditioning a thoroughly wrecked engine.

By *George H. Wallace*

PREPARATORY to leaving for a small town near by to indicate and make minor adjustments on an engine, I was packing my trunk when a sharp knock and "Telegrum, Cap'n!" caused me to hesitate long enough to receive the "telegrum" and tickle the itchy palm of the bellboy with the proverbial thin dime. The telegram instructed me to ignore the contemplated short job and to take the fastest train for a large plant in the South to offer "advice" for three or four days on a breakdown of some kind the extent of which was not mentioned.

Arriving at the plant early the second morning after a long ride through the mountains, the situation that confronted me was one on which advice was surely needed. A dose of water in the 70-in. cylinder of a cross compound 2000 kw. unit, had broken the 48-t. frame completely apart just back of the slide and pushed the cylinder with end of frame attached back about 5 in.

Damage Is Widespread

With the high pressure cylinder keeping the engine in motion for some time, further prolonged by the attendants attempting to close the throttle amid the exhaust steam escaping from a broken receiver connection, the low pressure cylinder skated back and forth considerable before the engine came to a full stop. Below is the extent of the damage found at the time and by closer inspection later on.

Main frame broken, and top slide cracked full length.
Twenty-three of the 28 flange studs broken off.
Twelve-inch piston rod bent twice.
Both metallic packings broken.
Tail slide broken.
Exhaust chest broken twice and one lug broken off.
Twenty-four in. steam inlet manifold broken.
Both 16 by 84 in. steam valves broken.
Both 16-in. exhaust valves chipped and cut.
All four ports badly cut and worn.
Oil pan under valve gear broken.
Four 2¾-in. foundation bolts badly bent.
Two 1¾-in. foundation bolts for oil pan, sheared off.
Exhaust connection to condenser broken twice.
Vacuum breaker broken.
Condenser moved an inch on foundation.
Expansion joint in exhaust line badly bent.
Base elbow under atmospheric exhaust pipe broken.
Cast-iron floor plates and concrete work broken.
Collars on crosshead pin wedge cracked.
Crankpin babbit cracked and wedge bent.

Naturally this state of affairs looked hopeless. One would have been justified in advising the owner to discard the entire low-pressure side, frame and all but the question of raising the shaft, wheel and generator weighing 220 t. in order to remove the broken frame and install a new one, even if the present 70-in. cylinder was retained, seemed to be an expensive undertaking with the facilities at hand.

"Can this breakdown be repaired?" asked the Local Manager.

"Certainly it can be repaired. There is nothing but what can be done, if somebody wants it done real bad and can finance the undertaking," I replied.

"Fix it," and that's that.

Thus did the four days contemplated in offering advice, develop into a lengthy proposition in actually putting into practice the advice which it was presumed would start the other fellow to work.

No Cranes Available

Since the 24-in. inlet manifold on top of the low-pressure cylinder was broken off at the flange, this part was removed, and a temporary exhaust line run from the top of the receiver to the atmosphere, in order to utilize the high-pressure side in developing as much power as possible to keep the plant in operation.

Originally the entire powerhouse had been erected "outdoors" with steam cranes and the building was assembled later. A crane of any kind in the plant was deemed superfluous and now that a new generation had succeeded to the management and operation of the plant, and days of trouble approached, all repair work had to be handled by chain tackles suspended from chains or cables strung between the roof trusses and changed frequently as location demanded.

As can be surmised, much of the material to be handled was of such weight that the trusses had to be braced to prevent collapse. Handling heavy parts and setting them to one side to make room for other work required considerable changing of chains and equipment.

To handle the boring bars in the 16-in. ports, the new valves when fitting them, and the steam and exhaust bonnets, 8-in I-beams were made from channel irons

and supported on suitable posts. From these, home made trolleys and a 1-t. tackle permitted handling the valves in and out of the ports and the front gear on and off as necessary in laying out.

Clearing Up

Naturally the first thing to do, was to take the job apart and note the extent of the damage more carefully. Chain tackles were rigged up and the remains of the tail slide removed and sent to the shop to be repaired as will be mentioned later.

The 70-in. back cylinder head was removed and set

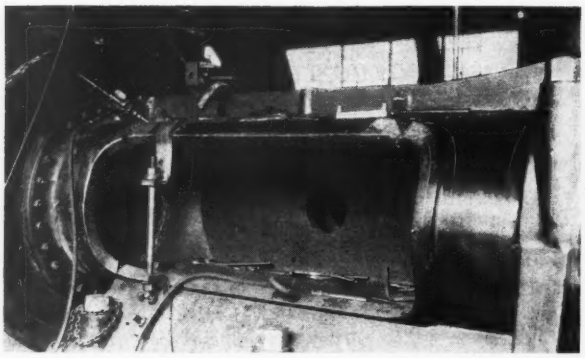


FIG. 1. GENERAL VIEW OF BROKEN FRAME SHOWING AIR DRILL AND CLAMP IN POSITION AND (LEFT) A CLOSE-UP OF THE BROKEN FRAME.

to one side. Three days were consumed in removing the piston and its badly bent 12-in. rod. The piston was removed and laboriously set to one side and the rod sent back to the builder, who was equipped to handle such work. It was straightened, a cut taken over it to remove the glazed spots (which were plenty) and then turned down to 11 15/16 in. Two complete sets of metallic packing were ordered to suit.

In the meantime preparations had been made to repair the broken engine frame. Electric welders engaged from a neighboring city, arrived with their equipment, and began to chip out the broken joints, ready to drill and tap.

Grout was chipped out from under the exhaust chest with jack hammers, a very difficult task, and wedges inserted after which the cylinder, with the broken end of the frame attached, was properly lined up to the slide.

Because the top slide was raised approximately ¼ in. by the accident the alining process was confined to the lower slide; the two side bosses at the crank end; and one at the back end as the other boss, being attached to the broken end of the frame, was of no use.

Welding Cast Iron

Drilling was started on the numerous cracks that had been chipped to approximately 45 deg., and studs ranging from ⅝ to ⅞ in. screwed in alternately about

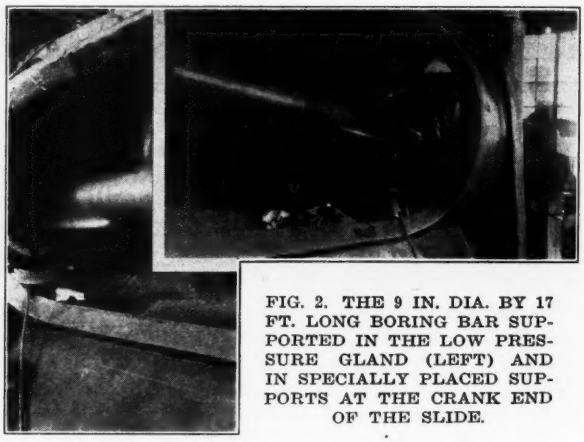


FIG. 2. THE 9 IN. DIA. BY 17 FT. LONG BORING BAR SUPPORTED IN THE LOW PRESSURE GLAND (LEFT) AND IN SPECIALLY PLACED SUPPORTS AT THE CRANK END OF THE SLIDE.

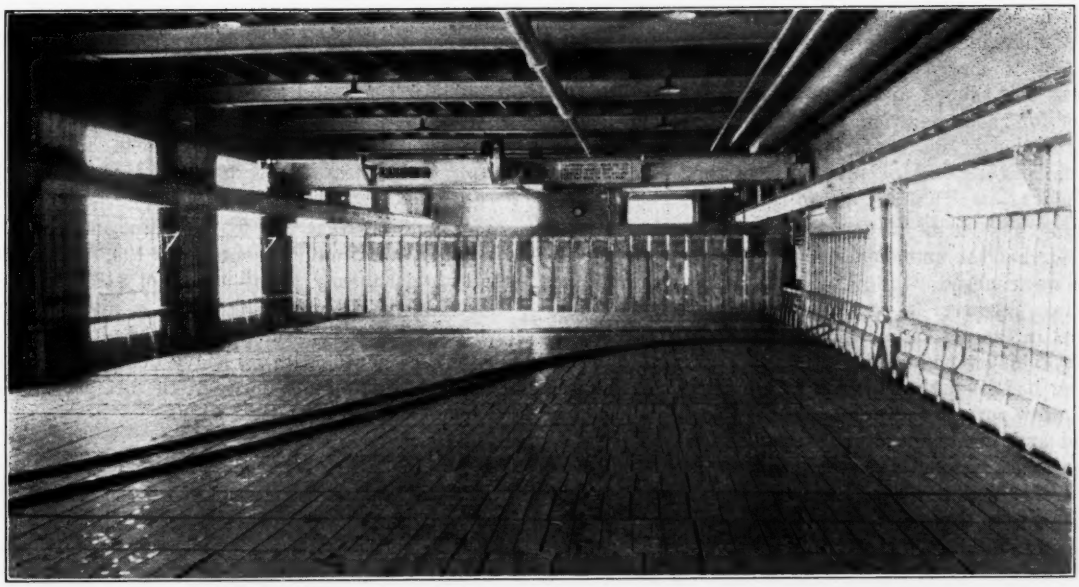
1½ in. apart to form, when welded, an interlocking joint.

Shrink links 1½ by 1¾ in. in section, with 1½-in. lugs 1½ in. long turned with an inward pitch on 8-in. centers were used at the joints, and the top slide joint, to strengthen the welds. They were set into chipped holes, at least half their depth, and on the outside were set in flush.

The cast iron was chipped away from the links, and ½ and ⅝-in. studs tapped into the iron around the links to make a perfect weld. Holes 1 17/32 in. in diam. were drilled into the frame a sixteenth more than the lug centers and the links set in hot enough to reach the holes.

As the top slide was raised out of place by the fracture, it was drawn down approximately to place with a 2-in. drawbolt through forged lugs bolted on. The original bore of the slide at the crank end, away from the full effect of the fracture was 36.125 in. After reboring it was 36.390 in. A bar 9 in. diam. and 17 ft. long with the bearings of the bar held in the cylinder gland and at the crank end of the frame by heavy steel bars set in to suit, was used.

While the engine was operated as a single-cylinder unit all during the preparation and 23 days of welding, owing to the location of the driving mechanism at the crank end of the bar, it was necessary to shut the engine down during the actual boring of the slide. Except for this and again for another three days while setting the valves, checking up, and putting on the low-pressure connecting rod the engine operated continuously throughout the repair period.



Factors Affecting Production Costs *in* Ice Plant Operation

By
A. G. Solomon

IN THE ICE manufacturing plant, the actual total operating cost of production plays an important part in the profits or loss to the owners. When the cost of making ice or producing refrigeration for cold storage is considered, the principal items are power or fuel and labor. We all know that the cost of power or fuel is the greatest single cost that goes into the ton of ice. Next is the labor cost. The cost of the ammonia, oil, salt, calcium, water, waste and the common plant supplies is really a very small part of the total cost.

This article is written to make clear that the power or fuel cost and the labor cost are greatly affected by the manner in which the seemingly unimportant items are used. Ammonia in the system is discussed in this article.

For convenience, we will have in mind an ice plant of 100 tons daily capacity. Under the average operating conditions this plant is easily able to show a low total cost of production. We will look at the results that are being obtained during the month of June. This will mean full capacity operation and must not be confused with the average for the full year. In this case the load factor will be 100 per cent. This means that not less than 3000 t. should be made during the month.

To all outward appearance, the plant is in excellent operating condition and the 100 t. per day should come easy. The power consumption is 50 kw-hr. per ton ice pulled. We will say that the labor cost is 30 cents per ton.

The plant has been charged with what was considered a full working charge of ammonia. There were no leaks in the system and the only ammonia loss was the slight leakage that occurred at the ammonia piston rods when the compressors got too cold. This loss was scarcely noticeable as the freezing back did not happen often. The first week of the month went by and the plant behaved in a manner to make a good showing. But no more than 100 t. could be made although the cracking temperature of the ice was 10 deg.

First, the tank temperature had been held at 14 deg., but after the first week the temperature began to move up a little every once in a while. This, however, was not enough to cause worry, and very little attention was paid to the slightly changed condition.

Just a few days later, the average temperature was hanging between 15 and 16 deg. As the tanks contained just enough cans to demand a 14-deg. temperature to make 100 t. of ice, the rise in temperature showed itself in the unfrozen top of the ice.

This hollow in the top of the cakes was the cause of complaint and a few hours' pulling was missed to allow the ice to become solid. This day the pull was 93 t. instead of the regular 100. The engineer told himself and the crew that they would make up the loss in a few days; but the next few days showed that it was not possible to pull 100 t. solid ice every day. The weather was blamed as the outside temperature was a little higher than it had been at the beginning of the month. The cooling tower was a good place to lay more blame. The operating engineers, both day and night, were

anxious to get the ice and they changed the expansion valves more often than had been the regular practice.

This irregular feeding of the ammonia made matters worse as it caused the back pressure to vary a few pounds both above and below the pressure that was proper for good operation. The temperature and degree of saturation of the vapor going to the compressor did not remain the same for any length of time. This variation caused more leakage at the rods.

After a week of this unsatisfactory running, it was decided that the ammonia charge was low. One 150-lb. drum was charged. On looking at the glass on the liquid ammonia receiver, it was seen that the ammonia just showed in the bottom of the glass. Another 150 lb. was put in. This livened up the system and as below capacity pulling had been the rule for several days, the ice was solid a few rows ahead. The next day the full 100 t. was pulled and the temperature stayed at 15 deg.

But the system was still short of ammonia. The liquid seal was not effective more than half the time so the evaporating coils were not flooded with real heat absorbing liquid. A light gas passed from the condenser, through the liquid receiver and expansion valves and into the coils of the ice tank. This gas is not capable of carrying heat and is simply superheated and then passes on to the compressor. This superheated gas is not loaded with heat taken from the water in the cans. But still it occupies space and must be compressed.

During short periods, the liquid showed in the glass and at such times the outlet from the receiver was submerged in liquid and the ammonia that went into the evaporating coils was real heat absorbing liquid.

Regulation of Expansion Valves

During one of these periods the engineer noticed that the back pressure was 18 lb. and he decided to gain a little by increasing the load by carrying 20 lb. He opened three expansion valves just a little. In about 10 min. the rods on one of the machines began to leak ammonia badly. The compressor was too cold and this was the signal that too much liquid was being fed into some coil. Not being able to make a good guess as to just which expansion valve was open too much, the three that were opened a short time before were closed a little. The leakage at the rods continued for about an hour and not less than 25 lb. ammonia was lost. By the time the freeze back was stopped the back pressure had fallen to 12 lb., owing to the pumping down of part of the system; and good work had not been done on the ice tanks, as was shown by the temperature having crawled up to 18.

On looking at the receiver, it was seen that the glass was ¾ full. Some of the expansion valves were again opened. This constant changing of expansion valves, leaking rods with resulting ammonia loss, pumping down and carrying varying back pressure is common practice when the charge of ammonia is not sufficient to provide a liquid seal in the receiver at all times.

Often, however, even with a good charge of ammonia, the liquid seal is not maintained. This is due to improper regulation of the expansion valves. The ammonia is often allowed to travel too fast and condensation is not complete in the condenser. This fast travel will keep the liquid receiver empty and will give indications that there is not enough ammonia in the system.

To obtain good results and a low cost of production, it is absolutely necessary to have a working charge of ammonia at all times. Do not wait to put in ammonia until the plant is about down and out. See that the ammonia is there and so prevent waste of money.

In the case being used as our example, the ammonia charge should have been brought up to full at the first sign of temperature going up. Perhaps 5 or 6 drums were needed.

We will say that 900 lb. were put in. At 15 cents a pound, this would amount to $135. Add $25 for freight and hauling, giving a total of $160.

During the month of June, this plant failed to produce 200 t. of ice for which it had a ready market. And during this month, with its heavy demand and low cost of both production and delivery, the net profit on every ton made should be at least $1.50.

Why Loss Is So Great During Summer Months

We will get away from our subject a little to see just why the actual loss is so great during the midsummer months. The ice business is strictly seasonal. During the winter months the plant sustains a loss on every ton of ice handled. The small volume of business means high costs and loss cannot be avoided. Then we find a few months of the year in which we break even. So during the summer months with the heavy demand we must exert every known means to have low production and delivery costs and to dispose of every ton it is possible for the plant to produce. We must make money while we are called on to make all the ice we can. Force everything to the limit during the ice season and benefit by the larger clear profits that can be reaped.

Back to our plant again; the direct and easily seen loss was an even $300 in our case for we failed to get the clear profit of $1.50 per ton on 200 t.

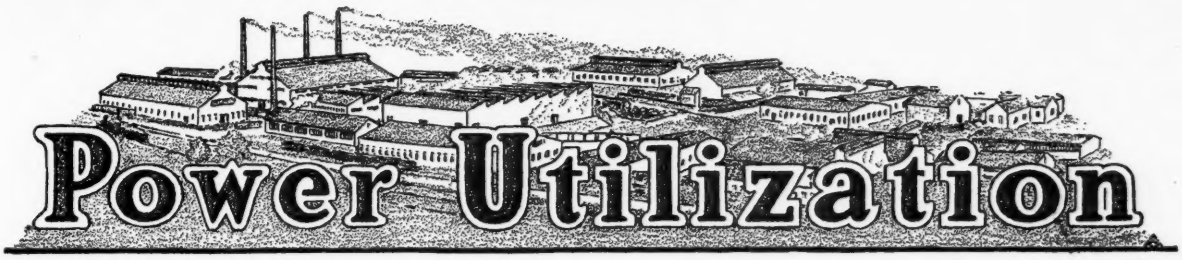
Next consider this. Operating the plant at reduced efficiency caused an average power consumption of 53 kw-hr. per ton instead of 50. At 1½ cents per kw-hr. this is an increase of 4½ cents per ton of ice pulled. During the month 2850 t. were pulled, giving a power loss of $128.25. The labor cost was increased at least 1 cent per ton or a total of $28.50.

Thus it can easily be seen that the direct money loss will be $300.00 plus $128.25 plus $28.50 or a total of $456.75. Take away the $160.00 spent for ammonia and the real loss will be $296.75.

But this does not settle the question. If the needed ammonia had been put in the system before the plant shiwed inefficient operation, it is reasonable to believe that the plant would easily have turned out 3150 t. instead of 2850. And the average power consumption would have been less than 50 kw-hr. per ton, and the labor cost per ton would also have been lower. The same amount of labor would have handled 105 t. per day and the daily pay roll would have been the same.

These facts and figures show loss that actually occur through little slips in operation of the ammonia system.

There is nothing strange or mysterious about the handling of ammonia in the refrigerating system. But every detail of operation of the entire plant must be carefully watched as every variation in condition, temperature, pressure, circulation, agitation, method of ice pulling and regulation of expansion valves has a direct and sure bearing on the working charge of ammonia.



Flow Measurement at Varying Pressure for Air and Gases

BECAUSE of variation of specific volume of air and gases with change of pressure and temperature, for conditions where these factors vary materially, a reliable method is to divert part of the fluid, proportional to the

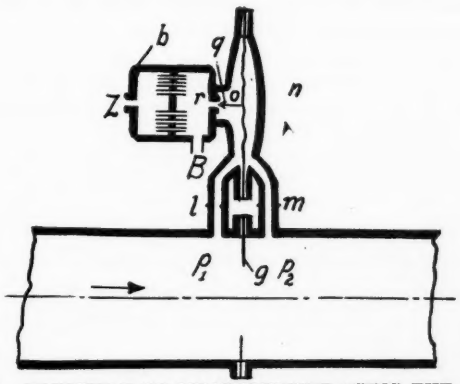


FIG. 1. PRINCIPLE OF MEASUREMENT USING THE FLOW DEVIATOR

main flow, and reduce that part to atmospheric temperature and pressure. Then measurement of the volume of flow of the diverted part is always under the same conditions.

This principle has been embodied in the Askania meters whose principle of action is illustrated in Fig. 1. Insertion of an orifice plate or Venturi nozzle in the main pipe results in difference in pressure before and after passage of the restricted area. Connection is made as shown to a flow deviator which has two chambers, *n* and *o*, separated by a light diaphragm which carries a needle valve *q*. Two small orifice plates, *l* and *m*, are inserted in the connection pipes.

With gas or air flowing, since pressure p_1 is greater than p_2, the diaphragm is forced to the right and valve *q* is opened to allow a small quantity of fluid to escape, sufficient to equalize pressures in *o* and *n*. Since *g* and *l* have the same pressures in front of and behind them, volumes passing them will be in direct proportion at all times and measurement of the flow through *l* will show the corresponding flow through *g* in the main pipe. The use of *m* is merely to synchronize the flow to chambers *o* and *n* during sudden changes of pressure, so as to prevent overloading the diaphragm on either side, with possible resulting damage to diaphragm or needle valve.

Flow through *l* is determined by the size of its orifice, design of valve *q* and the capillary resistance through the passage in cartridge *b*. These dimensions are made such that this flow is 1/500, 1/1000, 1/10,000 or 1/100,000 of the main flow as best serves. For use in different locations and for different pipe diameters, plate *l* can be changed, as necessary, while plate *g* is left permanently in the main pipe and is adapted to the conditions at the place where it is installed.

If all gases to be measured differ but slightly in temperature from the surrounding atmosphere, cartridge *b* can be screwed directly to the flow deviator as indicated in Figs. 1 and 2. For varying temperatures it is so connected that it can be changed as required for different conditions.

Flow through the cartridge *b* may escape to the air through outlet *z*, or, if record of total flow is desired, may be led to an ordinary gas meter as shown in Fig. 2. Pressure in chamber *r* will be in proportion to the flow through the needle valve and connection is taken off at

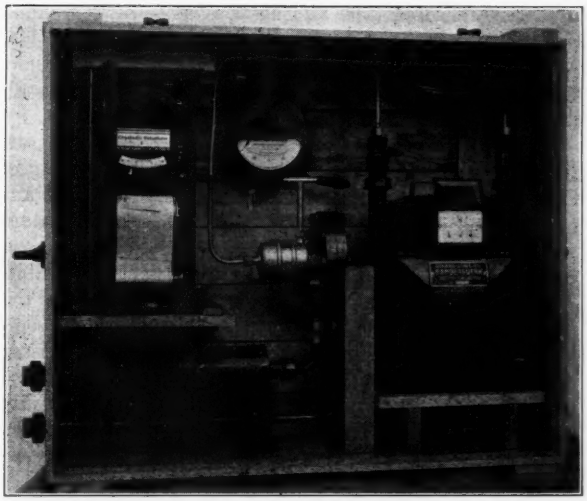


FIG. 2. COMPLETE PORTABLE MEASURING INSTALLATION FOR COMPRESSED AIR

B to an indicating gage, or a recorder or to both as in Fig. 2.

Five types of deviator are made, the lowest pressure range being from 2 in. water gage to 40 in. and the highest from 570 lb. per sq. in. to 3000 lb. Within its pressure range, each type can be used for small or large volumes of flow, by using plates *l* and *g* of different orifice sizes, selection to be governed by the size of the main pipe and the velocity of the gas or air flowing. Measurement is stated to be accurate from peak load down to 15 per cent of rated flow with a guaranteed error of not over plus or minus 2 per cent at minimum load.

For semi-permanent use, by inserting stop-cocks in the connection pipes to p_1 and p_2, the outfit can be transferred to various locations. It is also made in portable

form with meter, flow indicator and recorder, Fig. 2. Measuring orifices should, however, be installed permanently in the main pipe run whenever periodic flow readings are desired. For pipe over 1-in., a measuring flange is used; for 1-in. and ¾-in. pipe, a short insertion piece, carrying the measuring orifice and easily screwed into the pipe run is provided, specially useful for checking air consumption of individual tools.

Electrical Maintenance Program—I

CARE OF MOTORS AND STARTERS; INSPECTION AND CLEANING FOR A 150 T. PAPER MILL WITH DETAILED INSTRUCTIONS. BY MARIN PHILLIPS*

UPKEEP OF PLANT equipment requires a definite maintenance program which should include training of the personnel, allocation of responsibilities and the issuing of necessary definite instructions for carrying out the routine work. Following is given the essential outline for a program carried out in a mill equipped with 10,000 hp. of motors in sizes from 3 to 250 hp., current being purchased from the power company at 3-phase, 25-cycle, 1200-v. and stepped down through transformers owned by our plant to 440 v. for motor operation. Three banks of single-phase transformers are used, those of 1500 and 4500 kv-a. being for motor and lighting, while a 5400-kv-a. bank steps from 12,000 to 2200 v. for operation of an electric boiler. Plant lighting is taken care of from the 440-v. bus through a 275 kv-a., single-phase transformer.

In the electrical crew are ten men, six in the operating department and four for repair work. The operating crew works in 8-hr. shifts, an operator and an assistant constituting each shift crew. Instructions for operators are written out and placed on file, thus acquainting new men with their duties and removing all chance for alibis.

At one time it was the practice for anyone about the plant to start and stop motors but this resulted in compensators being tied into the starting position, burning out transformer coils, also in the shutting down of motors by pulling the line switch under load, causing burns to workmen. As a consequence, operation of electrical equipment was turned over to the operating crew, which has worked out even better than expected in preventing costly repairs, delays and accidents.

Plant fire inspection, prescribed by the insurance company is made by the operating department, thus acquainting the operators with the fire fighting equipment, which is considered valuable insurance especially on Sundays and holidays when no one is in the plant except the electrical operators and the plant watchmen. Also when a sprinkler head lets go near electrical equipment, the operators know where to shut off the water without having to search for the valve.

In cleaning, motors are blown out with compressed air and afterwards motors and control equipment are wiped down. Belt repairs are made by a special man working for the master mechanic.

Operators and assistants as chief inspectors are held responsible for the general condition of all electrical equipment including lighting, motors and control equipment, also the cleanliness of such equipment and the condition of all motor-drive belts. Operators must remain on duty until relieved by their successors. For work which cannot be done by the operator, written memorandum should be given to the maintenance department outlining the nature of the trouble, with as much detail as possible as to how the trouble developed. Report conditions which can be improved with suggestions for such improvement. Leave record each morning of work out of ordinary done during the night or time lost by any drive. Operators must start and stop all motors except in emergency, taking care when starting to have the controller handle in the off position before closing the oil switch, also when shutting down to see that the oil switch is open and control is in off position before leaving the control equipment.

Routine of inspection to be as follows:

All heating fans to be watched closely for continuous operation and all machine exhaust fans to be running before machines are started.

Hourly: Read all meters, note temperature of transformers and cooling water and the operation of the electric boiler. Every 8 hr. examine all switches on the main switchboard for overheating and open blow-off valve on the electric boiler just a few seconds, then close.

Daily: Clean switchboard room thoroughly; make up power distribution report; inspect all motors twice and oil if needed.

Weekly: Clean all motors and control equipment; fill control and electric truck batteries with distilled water; test and charge batteries if needed; grease and oil idler pulleys.

Monthly: Examine calcium chloride breathers on power transformers and refill when caking is noted; make out monthly lamp costs; make fire inspection.

Day operators are responsible for keeping the fuse bin filled. Clean fuse contact surface with fine sandpaper when refilling fuses and replace a blown fuse with another of the same rating. Day operators are to keep a supply of clean rags, oil and sandpaper on hand for night and Sunday use.

Watch for rubbish collection back of switchboards and batteries. Refill empty fire extinguishers when used and in case of fire in any part of the mill kill any feeder lines that expose fire fighters to danger. When power fails, shutting down the plant, get the boiler house and main water pump motors going as quickly as possible.

On Monday morning, generators and exciters are to be started and voltage built up so that they are ready for use when needed, but no beaters, pumps, or machine drives are to be started until asked for by the proper authority.

When a motor is disconnected for removal, draw oil out of the bearings to prevent spilling, also when a motor is started that has been down watch the oil a little and note whether oil rings are turning. On a new installation, watch the bearings and oil rings for 30 minutes.

MOTOR INSPECTION AND CARE

If, due to trouble in the circuit breaker, it becomes necessary to block the compensator in, watch the motor carefully to see that it does not overheat. When a

*Electrical Superintendent, International Paper Co., Niagara Falls, N. Y.

starter or oil switch in the plant is blocked in, put a danger tag on the switchboard oil switch which controls the feeder to the blocked-in control; also report promptly the necessity for resorting to this method of operation. Watch for and report on cutting of commutators, the vibration of motors, sparking brushes, heating motors and on bare wires or badly insulated connections. Also report on repair of motors and on control equipment found with disconnected or broken ground wires. See that motor covers are kept in place and replace the safety guards removed from belts or pulleys when making repairs. If motors have push button stops, use them when shutting down and report any control equipment that does not trip out with the push button or on power failure.

If a relay plunger works loose, changing the setting so as to cause the starter to trip out, reset the relay to correspond with the ampere setting of 25 per cent overload. Be sure also that the relay dash pot is filled with oil and that the time limit setting is in position to take care of momentary peak loads.

Cleaning Routine

Cleaning is divided among the shifts as follows: For the 7 to 4 shift, all motors and controls in beater room and machine room basements, in machine shop and blacksmith shop. For the 4 to 12 shift, boiler house, book stock, machine room and the digester building. For the 12 to 8 shift, bleacher department, waste paper department and cutter motors. In case a shift finishes its department, it should start cleaning in the next department and notify the relief where it leaves off, or if some cleaning has been impossible, notify the relief so that he can take care of it.

While cleaning, watch for signs of possible trouble such as hot or loose connections, poorly taped connections, defective wiring installation, broken or disconnected ground wires, condition of belts and joints, dripping water, oil leaks from bearings, broken, worn or loose parts. When cleaning around belts, pulleys, or other places where accident is possible, put a danger sign on the starting equipment. After doing repair work at night, put all ladders and tools back in place, also clean up dirt such as bits of tape and insulation.

Do not clean; (1) back of control equipment, switchboards, or other places with exposed live wiring; see that the switch is opened before doing such cleaning. (2) Around high-voltage switches or bus as the maintenance department will attend to this. (3) Do not attempt to work at night without help as needed; ask the night superintendent for assistance.

When cleaning, use an extension light to see clearly around brush holders, inside of bearing pedestals and for cables in pits. Make sure that no cables are lying on an oily or wet floor.

See that air is dry before using it to blow motors, but do not hold the hand under the air nozzle to test for dryness as a slug of dirt or scale may cause injury. Move brushes up and down in the holders before blowing out machines to dislodge dust, and carbon from brushes and holders. Note that all brush pressure springs are in place and that there is sufficient tension to give good contact with the commutator.

Be sure that oil well covers are in place and that the dust catchers are in place on the bearing housings. Be careful to blow no dirt, grease or oil into motors or bearings, also that oil is not blown out of the motor bearings by turning the air hose on the air gage on the end of the bearing housing. Wipe all dirt and oil from around the air gage, the bearing drain plug and the bearing housing and shaft, also clean up oil spots on the floor around motors and control equipment. Wipe off accumulation of dirt during the week, whenever the motor can be shut down without loss of production.

Do not attempt cleaning a motor while it is running. For heating or ventilating fans that are kept running Sundays, shut them down during the cleaning and start them up afterwards. Use no air hose with metal nozzle around any live duct work or wiring. Wear your goggles and respirator when cleaning motors to prevent breathing of copper dust and to protect the eyes.

Vertical Belt Drives

For drives whose center line is at an angle of over 45 deg. with the horizontal, grip of the belt on the lower pulley is affected adversely by gravity and centrifugal force. To make up for these effects, use of a wider belt than for horizontal drive, choice of a belt that is flexible and grips the pulley closely and, for step cones as used on lathes, a belt with soft interior ply for gripping and stiffer outside ply to prevent curling will be of help.

Excessive tension should be avoided. Where high tension is used, feeding lubricant to the bottom of the bearings of the lower pulley, from a source located above the top of the bearing will tend to prevent stoppage of lubrication at the top of those bearings, where pressure is greatest due to the upward pull of the belt.

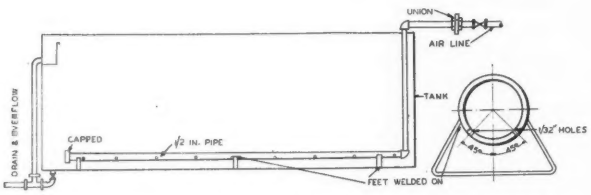
Across-the-Line Motors

Introduction of across-the-line type induction motors has made possible a considerable saving in cost in the combined price of the motor and starter of from 6 to 32 per cent in the 7½ to 30-hp. sizes for which this type of motor is regularly listed. Also this combination of across-the-line motor with push-button control offers some advantages. Maintenance is low because of the simple starter construction. There are few parts to inspect and renew. Push-button control affords great convenience as push buttons may be placed close to the operator with additional buttons in remote positions for emergency stopping. With a given current, the starting torque of the across-the-line motor is larger.

Welded steel construction was used for framework of a house in Cleveland, O., which has just been completed. It is two stories, of French architecture designed by George H. Burrows, 3-in. light channels and 6-in. light standard Carnegie beams being the principal shapes. All steel was cut to size before delivery, fabrication and erection welding being done at the site by electric welding. Complete erection was estimated as 2½ working days for one welder and three structural iron workers. The architect states that cost will be 40 cents a cubic foot or $72 more than for usual wood framing with the advantages of no sag or shrink and increased fire resistance.

Cleaning Solution Agitated by Compressed Air

SOME TIME ago, our spray department ran into some particularly difficult parts to clean and it slowed them up considerably because of the extra soaking time needed. We thought that good active agitation of the solution in the vats would help them and rigged up some compressed air agitators to help out in emergencies. The agitators consist simply of two ½-in. pipes running the length of the tanks about 5 in. from the bottom.



ARRANGEMENT OF AIR SPRAY FOR AGITATING LIQUID

These pipes are drilled at an angle of 45 deg. downward with a 1/32-in. hole every 1½-in. of pipe length, arranged alternately on each side of the pipe. This spacing would be a matter of the desired agitation. We figured the spacing so as to give the area of the drilled holes about the same as the area of the pipe. Pipe must be capped.

Pipes are supported on the bottom of the tank by triangular shaped pieces of old ½-in. plate that we had and which were welded on the pipe as shown. This makes a good heavy weight that stays in place. As the air is needed only occasionally, we put a union in after the valve so that the pipe can be taken out or connected up in a few minutes time. The workmen do not like to use it except when forced to because they say it cools the solution somewhat and uses more steam, which is of course reasonable. If one of these agitators is used often, it would be desirable to increase the heating coil surface or increase the steam pressure.

Springfield, O. F. PAUL.

Coal Quality and Stokers

MR. VAN BRUNT'S article in the July 15 issue of Power Plant Engineering is a very able one and the writer is to be congratulated on his knowledge of the various types of fuel burning equipment. I would, however, like to comment on some of his statements and also add a point or two.

It was stated that "no stoker will handle with equal facility many different kinds of fuel, whereas practically all bituminous coals may be burned equally well in pulverized form but not at the same rates of combustion." The crux of the matter is in the last part of the sentence and my experience has been that the same statement is true for underfeed stokers and is continually being done successfully.

It is quite possible to design an underfeed stoker installation so that it will handle the worst of the coals under consideration and then it will be successful on any of the better grades. It is only when the converse is done that trouble is likely to arise but even then not necessarily so, as was found out recently when a large holding company operating a modern pulverized fuel plant with a certain coal, for which it was specially designed, decided to try to burn the same coal in one of their stoker fired plants which was 7 yr. old.

Operators at the stoker plant expected all sorts of trouble, but were surprised to find that at the same combustion rates that were used with their good coal, they had no trouble with the poorer grade, and it was only when they tried to run the stokers at a fuel rate over twice as high as was their custom with good coal, that the lower grade presented any difficulties. The efficiencies at equal fuel rates were also the same.

Iowa coals having a fusion temperature of less than 2000 deg. F. have been burned for years on underfeed stokers in a number of cities in Iowa and these plants are undoubtedly successful since one of the companies operating a number of different plants throughout that state has consistently put in underfeed stokers in their new plants whenever they were constructed.

Also in Europe where the fear of war is always reflected in power plant design and they have to burn a wide variety of coals, most of which in America would be classed as among the poorer grades, it has been found that stokers burn satisfactorily the wide variety necessary. During the past 3 or 4 yr. the trend in Europe has been quite definitely to stokers, as is witnessed by the fact that London, England; Berlin, Germany; Paris, France; Genoa, Italy; have all chosen to put in underfeed stokers and in each case a condition of the installation imposed by the government of the country in which the plant was built, was that it should be able to burn any type of coal available.

The author restricts good operation with pulverized

fuel to a B.t.u. release rate of 18,000 lb. per cu. ft. of furnace volume, whereas no engineer would consider that he could possibly afford to build the large combustion chambers this release rate requires if he were building a stoker plant.

In speaking of preheated air, the article states that temperatures of 500 to 600 deg. F. are too high for stokers, but a large plant in Philadelphia has had stokers working at these temperatures for 5 or 6 yr. and is at present installing a stoker to use air up to 750 deg. F. temperature. Also the Bewag Company in Berlin, Germany, installed the largest underfeed stokers in the world for an air temperature of 600 deg. F.

Philadelphia, Pa. E. J. HUSTED.

Care Is Needed in the Selection of Equipment

GREAT RESPONSIBILITY rests with those who purchase plant materials and equipment, if the company is to be best served. This responsibility becomes greater from year to year, due to so many varied lines of equipment all serving the same purpose.

The maintenance department being vitally interested in obtaining mechanical equipment that will give the best service and require the least amount of maintenance work when installed, has to give careful study and close coöperation with the purchasing department. To obtain this equipment is a job in itself.

When equipment is needed, the general procedure is to submit the requirements to different manufacturers for bids. In some cases this is done without a clear statement of the specifications that must be met as to the quality of materials, or the exact conditions under which the equipment will have to be operated. Then, again, unless care is exercised, there is a natural tendency to award the order to the manufacturer who has submitted the lowest bid. This should not be done without first taking into consideration the quality of the equipment, the cost of upkeep after it is installed, or whether it fully meets with the specifications and requirements.

It is natural that the first cost of a new installation be dreaded, as it means spending hard-earned money; but that money is spent for the purpose of making more with it and when the installation is completed, the only way to do this is to keep the wheels turning day in and day out. The cost of maintenance is certainly worth careful consideration.

After all is said and done there is comparatively little difference between the cost of a good installation and that of a so-called cheap installation that will prove to be unreliable when installed, certainly not enough to let price alone be the deciding factor. The cost of maintenance and repairs may be only a small amount compared with the time lost in production by the machines when they are shut down while repairs are being made to the equipment that drives them.

Take electrical equipment as an example: As a general rule, motors when properly applied and installed and given a reasonable amount of care and attention, will operate satisfactorily and give little trouble. The starting equipment and switches controlling the motors are the most important items to take into consideration and should be selected with great care, keeping the following points in mind as a basis to select from:

How long will it take to change the contacts? Are all of the contacts made accessible for inspection and changing when the cover is removed; or, will part of them be hidden away behind coils and the like, so that the starter will have to be taken apart unnecessarily to get at them?

Another important point is, will the parts be interchangeable for three or four different horsepower ratings so as to reduce the number of spare repair parts to the minimum?

It is not uncommon for a small switch or controller to be part of the control for an important machine that is producing from $200 to $300 worth of products per hour. Keeping this fact in mind, it is readily seen that every minute is precious and counts, while the control is out of service for repairs. This is becoming more than ever due to scheduled production and high unit output per workman.

When starting equipment has all contacts, coils and connections in plain view and easy to get at when the cover is removed, the cost may be from $75 to $100. Another one of the same capacity may cost $50 to $75 but having some of the parts in inaccessible places, it is awkward and difficult to repair and inspect. It is evident that the latter type is going to consume more time when trouble develops. The making of repairs and adjustments and the extra maintenance cost will consequently amount to more than the difference in cost between the two starters, to say nothing about production time lost.

Niagara Falls, N. Y. MARIN PHILLIPS.

The Power Plant of the Future

IN THE JULY 1 number of Power Plant Engineering, the editorial under the above heading is interesting but over my head and, I am afraid, over the head of its author. In the last two sentences, I find this:

"The power engineer will be safer, if he regards his present methods as a point near the lower end of a long upward curve of development. Then he will not be surprised at anything that happens."

I prefer to belong to the old school in which I was taught that efficiency is equal to output divided by input and that efficiency greater than 100 per cent is impossible. I am willing to accept the first sentence quoted above but not the last sentence. I shall be surprised if any such thing happens as "explained" by your dream editor.

Belief in the "atomic power plant doctrine" (or whatever it is properly called) is likely to cause us to begin wasting fuel. We are wasting too much fuel already without cutting loose from facts as we know them and wasting fuel recklessly. There is only one thing that causes me concern for future generations and that is the almost pitiful rate at which we are wasting fuel in our manufacturing processes. It is all right to buy a hundred times more clothes than we need because we are helping the other fellow in so doing. It is all right to buy 10 automobiles a year if we want to and if we can pay the bills. But the manufacture of those clothes and cars has caused the irretrievable loss of a certain amount of fuel. That is the one and only thing for

which I cannot find a plausible excuse. I wish that I could find an excuse.

Probably there *is* a prodigious amount of energy in atoms but I maintain that it is going to be exceedingly difficult for our scientific friends to get it out. First there is the problem of releasing the energy and then comes the problem of harnessing it. How will they do either? I am skeptical.

As things now stand, we cannot utilize 100 per cent of the energy in coal, oil and potential water power—energy that is virtually handed to us on a platter. Fifty per cent is about the maximum modern accomplishment of converting heat into work. That being the case, doesn't the utilization of atomic energy look like a hopeless task? Nature has never yet given us something for nothing and it isn't likely that she ever will. Nature's laws are unchangeable.

My prediction is this: If a method of releasing and harnessing atomic energy is ever discovered, more energy will be required to do the releasing and harnessing than is contained in the original atom.

Newark, N. J. W. F. SCHAPHORST.

Oil Thrown from Bearing Destroyed Commutator Insulation

ROUGH BLACK spots persisted in forming at nearly equal space intervals roundabout the commutator of a large direct-current generator. Apparently, the spots were due to the burning effect of short circuits and arcing in the regions where they occurred. But the operating engineer was at a complete loss to account for the cause of the short circuits. Nothing seemed to be wrong with the connections between the commutator and armature, but to make sure that the connections would be right the engineer resoldered all of them. He also tightened the commutator bolts and readjusted the brushes, discarding the original set of brushes and experimenting with others of different texture. But still the black spots continued to reappear as often as the surface of the commutator was ground and sandpapered to smoothness. At last the mica insulation began to disintegrate and work out from the ends of the commutator, leaving cavities between the segments. It then was decided to attach a new commutator. When the old one was ripped apart the cause of the black spots was apparent, the commutator being thoroughly oil-soaked.

Oil that did the damage was thrown from a ring-oiled bearing that was getting much more lubrication than it needed. The maximum level of the oil in the well of a ring-oiled bearing is determined by the height of the overflow orifice. In this case the overflow pipe stood too high. Being deeply immersed, the rings carried more oil onto the journal than could flow off in the regular way; hence a lot of it was thrown out endwise. All that was necessary to mend the difficulty was to lower the overflow orifice by shortening the pipe one inch.

In filling the well of a ring-oiled bearing, the oil should be poured in through the overflow pipe instead of through the opening in the bearing cap. The opening in the cap is put there principally to permit a view of the rings while the machine is running, not for convenience in replenishing the well. Filling through the overflow avoids waste of oil, for the level then rises simultaneously in the well and pipe and a brimful pipe is the sign to stop pouring. None of the oil runs to waste.

Not so when the oil is poured in through the opening in the bearing cap, for then the sign to stop pouring is the issue of oil from the overflow pipe. Retardation of flow through the restricted overflow channel keeps the oil from climbing as fast in the pipe as in the well; hence, when the job is done, there is an excess of oil in the well. Running out through the overflow, this excess is lost, usually, by mopping it up with a bunch of waste and tossing it into a boiler furnace.

Oil reaching the inner surface of a commutator by creeping along the shaft from a flooded bearing may destroy the mica insulation to the extent of causing the segments to become grounded to the shell, particularly if the machine is one that operates on a ground-return circuit.

Applying a little oil now and then to the brush surface may help to produce a nice polish, but it is better to depend for this upon the lubricating quality of the brushes. Self-lubricating brushes that do not give up their lubricant too freely are to be obtained. In applying an oil-soaked bunch of waste or an oily rag to reduce friction and screeching of the brushes, the operating man is apt to overdo the thing. Too much oil so applied is worse than none at all, because of the injurious effect on the insulation.

St. Louis, Mo. A. J. DIXON.

Sand Blast Thought Injurious to Boilers

IF THE SAND blast cleans the surface of the tubes as clean as a gun barrel, as stated in the letter from R. S. Leach on page 816, August 1 issue, its use would not be advisable under certain conditions.

Mr. Leach does not tell us the nature of the fuel used in the boiler furnace. Polished tube surface is not a desirable condition when a soft coal with a considerable sulphur content is used as fuel.

Mr. Leach states that he thinks the sand blast to clean boiler tubes should be used more often than is done. One of the reasons it is not more in use is because there are safer, less expensive methods available.

In a horizontal return boiler, every time the tubes are sand-blasted as clean as a gun barrel, an infinitesimal part of the tube surface would be removed. Although this might not weaken the tubes to any appreciable degree for a short time, it certainly would do so after a more or less extended time. Cleaning the tubes twice a month when soft coal is used would be inadequate. If a sand blast were used on a horizontal return tubular boiler using soft coal frequently enough to keep the tubes clean, say every day, I am inclined to the belief that the safety of the boiler would be lessened to no inconsiderable extent by such a process.

Toronto, Can. JAMES E. NOBLE.

BROOKLYN EDISON CO. has placed an order with the Westinghouse Electric and Manufacturing Co. amounting to approximately $650,000, consisting of 124 low voltage a-c. network units of the latest type. The primary voltage will be 27 kv. stepped down to 125/216 v. Each unit consists of a 500-kv-a. transformer with a CM-2 network protector mounted on it.

Questions and Answers

Furnaces for Gas Firing

WE ARE ABOUT to change over to natural gas and would like to know how many cubic feet of combustion space should be allowed for rated b.hp. and what the maximum allowable heat release should be made.

C. T. M.

A. In the past, it has been customary to figure 1.5 to 2 cu.ft. of furnace volume per rate of boiler horsepower per hour. Taking the boiler horsepower as approximately 33,000 B.t.u. per hr., this would be equivalent to a heat release of from 21,000 to 16,000 B.t.u. per cu. ft. at 100 per cent rating.

This will be recognized as an old rule of thumb method developed in the period when boiler rating rarely exceeded 100 per cent. In the December 15, 1930 issue will be found data regarding six natural gas installations completed during 1930 in various parts of the country. The furnace volume varies from 5 to 10 cu.ft per b.hp. One, Devil's River plant, has an 8400-cu.ft. furnace for an 865-hp. boiler. Figuring from the steam output, the maximum boiler rating is about 400 per cent but the maximum heat liberation is held to around 16,000 B.t.u. per cu.ft. per hr., or about the same value figured for the 2 cu.ft. per b.hp. in the old rule and thumb method.

Obviously, the rating at which the boiler operates will depend upon the furnace volume and the heat release per unit of volume. With a conservative maximum heat release of 15 or 16 thousand B.t.u. per cubic foot, the furnace can be made of such a size as to enable operating the boiler at the desired rating. This rating will depend upon the type of boiler and the amount of steam desired. If the boiler is already installed and the demands for steam considerably above the former rating, it might be advisable to build a larger furnace, operate the boiler at high rating and install an economizer or air heater to bring down the temperature of the flue gases. If the boiler is already installed and has sufficient capacity to meet the demand, the desired rating is already known and the size of the furnace can be easily calculated.

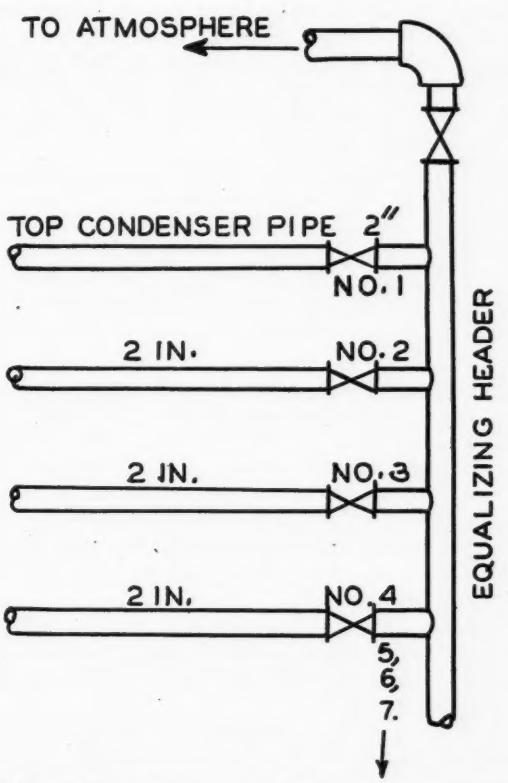
Turbine Heating

WHAT IS the reason a turbine gets hot if not enough steam passes through it? This is more noticeable on our noncondensing machine. Is it caused by the friction of air on the blades and if a perfect vacuum were possible would there be no heat produced? R. C.

A. Your understanding is correct that the heating of a turbine when insufficient steam is passed through it is because of friction of the air on the blades. The steam passing through furnishes a medium for carrying off this heat, whereas, if there is no passage of steam, the air is simply heated and heat can only escape by radiation.

High Head Pressure

REFERRING to the question of A. B. J. on page 775 of the July 15 issue, the high head pressure is undoubtedly caused by air. The length of the 1¼-in. pipe to the receiver makes little difference if properly installed and insulated. If the suction pressure is carried below 5 lb. and the compressor piston rod stuffing-box is not oil sealed air will get in the condenser with either vertical or horizontal machines.



VALVE ARRANGEMENT FOR PURGING CONDENSER

To blow the air out of condensers of the type with an equalizing header as shown in the sketch, close all valves from 1 to 7 and open the valve to the atmosphere. Then gradually open valve 1. When the pipe on the header side feels cold or is frosted, the air is all out. Close valve 1 and repeat the process with each of the others.

Shutting the ice machine down for an hour with the water running over the condenser is the best way to get the air to the top of the condenser.

Taft, Cal. JOHN W. DAY.

Editorial Comment

Unemployment

Right now we have it as a serious problem with the solution awaiting, apparently, the revival of business. Questions to be answered are: How can it be reduced now as much as possible? How can it be overcome as rapidly as may be with increase of business? Also how, in future, can recurrence of unemployment be avoided or minimized?

As to the first, all sorts of answers are being put forward, pushing of public works being a favorite suggestion, which is admirable, if the public works are such as are desirable to build and can be afforded. Running communities into expenditure which they ought not to afford cannot be justified, however, and is sure to result later in economic difficulties.

Aside from public works, rehabilitation of industrial plants seems to offer the most promising opportunity for using workers and, if wisely planned, is almost certain to be profitable in the future. Enlargement of capacity, however, is of doubtful advisability unless an increased market is certain with business revival, since over-increase of capacity to produce is blamed by some economists as a factor in causing present conditions.

Spreading work available among the greatest possible number of workers is a method that has been quite generally followed by adopting short days or short weeks. While this adds nothing to total employment, it distributes the burden more equally and the logical sequence would be to add workers on a short-hour week to the payroll as business improves rather than increase the hours worked, until requirements permit full time operation.

This brings up the question of whether our productive capacity has so increased that production from a shorter-hour week is all that can be disposed of until population increases.

It is interesting to consider the answers of some industrial leaders to the economic problem of small industries, as presented at the Conference of Smaller Industries held at Lake George recently and one answer to the shorter hour problem as advanced by Ralph E. Flanders is a good place to start. He begins with the premise that maintenance of wage rate is desirable to keep up purchasing power, although he admits that, if commodity prices continue to fall, lower wages will of necessity follow. He proposes a 40-hr. normal week with 50 per cent added rate for overtime up to 45 hr. and 100 per cent added rate above that, the object being to stimulate employment of as many workers as possible rather than use of overtime. He also feels that such penalty for overtime will act as a check on tendency to overproduction as demand increases, feeling that such overproduction is often a grab for immediate returns, that later reacts toward dull business. While this solution seems simple, when one tries to follow the probable effect on cost of production and the result on market for products, it becomes confusing, since other authorities contend that our industrial salvation depends on reducing the cost of products so as to broaden markets. The logical answer seems to be adoption of such wage rates and working time as will give to each worker the largest return in what he wishes to buy. This involves the price at which each product has to be sold to other workers in order to make a market for that product and the working out of the answer as to wages and hours falls back on the law of supply and demand which nobody has yet been able to overturn.

Discussing future avoidance of unemployment, several speakers agreed that some form of insurance or guarantee fund is essential, the desirable plan being for each organization or trade group to set up a coöperative system which shall accumulate funds during good times sufficient to tide over dull times. This may be done by each corporation or by a trade organization for several corporations. The advantage of the latter is greater stability and diversification of conditions and the possibility, as pointed out by Philip P. Gott, of association influence to avoid overproduction. Unless some change is made in present laws, so that the smaller organizations may coöperate for effective control of an industry, such organizations will be increasingly forced into mergers and combinations, in spite of the fact that during the depression of 1920-21 the decline in wages in large factories was over twice that for small factories.

Unless industry devises, voluntarily, some means for solving the unemployment problem, James W. Hook voiced the opinion that laws will be passed making insurance compulsory. His suggestion was that study be made of the funds necessary to accumulate to keep steady workers employed from 60 to 80 per cent of the time during depressions for 52 weeks, then provide for establishment of such funds, preferably by payments from both employers and workers. While isolated plans have been tried out, Dr. Royal Meeker stated that no real general progress has been made toward stabilization of employment and that what is needed is regulation of production as well as setting up of safeguards for insurance. General action is needed since most of the hazard of unemployment comes from economic and social conditions over which the single organization has no control. While that is true, it does not preclude the possibility of each organization adopting a plan to care for its own workers and conditions but setting up a fund to pay 60 per cent wages over an unemployment period of 52 weeks would seem beyond the possibilities of most organizations, unless the accumulation period were spread over a longer time than has recently been common between depressions.

Considering the whole situation, present and future, the part of wisdom seems to be so to arrange employment during the period of recovery as to work the least hardship to workers and reduce hardship to the greatest number as rapidly as possible. Then, when conditions are such as to permit, begin on a well considered plan to stabilize steady growth in each branch

of industry, avoiding overextension and to set up funds which will care for unavoidable dull periods. Such care should be as adequate as possible but should be based on coöperative action of the workers, the ratio between their payment and that of the employing organization to be determined by the conditions in each industry. Now is the time for planning so that the forces for avoiding and relieving future unemployment may be put in action as soon as the present period is past.

Do We Need a New Industry?

Commenting on the present industrial situation, one of our leading bankers remarked some time ago that one of the things that would do most to pull business out of the valley of pessimism in which it now languishes, would be the creation of a brand new industry, the rapid growth of which would stimulate activity in many related lines.

He called attention to the fact that the rapid growth during the past 20 yr. of the automobile business and during the past 10 yr. of the radio business provided exactly the sort of stimulation he had in mind. Not only was the growth of these industries rapid, but they also affected many related industries, thus stimulating the entire economic structure. Without question this suggestion merits the most thoughtful consideration, especially in view of the fact that we have at present two infant industries that may assume this role of stimulator.

It has been thought by many observers that one of the industries that is destined for unusually rapid growth is aviation, particularly since the introduction of the autogyro. If the aviation industry is to be the stimulating agent, however, it does not as yet show signs of sufficient energy to pull the rest of the economic structure along with it. Just why this is so is difficult to explain. Europeans, especially, are amazed at the apparent lethargy of the American people as a whole in adopting this new form of transportation. They agree that while the total aviation activity in this country is undoubtedly great, it is not nearly as great in proportion to the size of the country and the amount of our business activities as it is in many parts of Europe. Whether or not this is just another rubber-stamp European criticism, we are not prepared to say.

It would seem, however, that we have another budding industry that may prove to be an even more important stimulator of activity than aviation. We refer to air conditioning, especially as it relates to dwellings. During the past two or three years, the question of automatic heating of houses has engaged the attention of the general public and the various manufacturers of oil burners, domestic stokers and gas burners have had unusually good success, in spite of the depression that has existed in other lines of business.

Every engineer knows, of course, that there are air-conditioning equipments now on the market suitable for use in homes and commercial buildings. There is scarcely a city in the country boasting fairly good-sized office buildings in which air conditioning equipment has not been installed, nevertheless the idea of a large-scale development of domestic air conditioning has not yet taken hold.

When it does, however, it will doubtless spread rapidly. The market for such an industry is tremendous and, as noted above, activity in such an industry would be reflected in many other fields, such as those of sheet metal manufacture, electrical equipment, piping and insulation. For the past two or three years, engineers have been much interested in air conditioning for general commercial purposes and in industry the art has developed to a high state of perfection, with many resulting economies and advantages. In short, the air conditioning industry, as a whole, is just about in the same position in which the oil burner, gas burner and small stoker industries found themselves prior to 1920 when there were many good industrial installations of this equipment but few good domestic installations. If the air conditioning developments follow the same lines, without doubt they will furnish the important stimulus to general economical activity that so many observers seem to feel is needed.

Rapid Changes in Power Equipment

Every important industry goes through periods of rapid changes. These changes are brought about by advances in science, economic readjustments, social and political upheavals, unpreparedness for disastrous occurrences in nature. The power industry is no exception. During the past decade a vast amount of pioneering has been going on, only a comparatively few plants, however, are now equipped with the most efficient equipment available and the operating personnel capable of securing the highest economy of which the plant is capable.

During recent months manufacturers of power plant equipment under the stress of competition have, almost universally, improved the designs of their products making them more efficient, more reliable, easier to operate and keep in good condition. When the demand for their products was enough to keep manufacturers satisfied with their profits, improvements, such as mentioned, seemed unnecessary and little development work was done. The stress of reduced profits have proved a wonderful stimulus to improvement in details of manufactured equipment; changes that have been in the minds of the designers for some time are now being realized.

As a rule, the changes made are not radical so they do not come into the experimental class. To engineers familiar with the old equipment, the changes are obviously in the right direction and provoke the question, "why did they not do that before?"

So today we have available on the market equipment that is superior in many respects to that available for the same purpose three years ago, as a direct result of the economic changes that have been taking place. These improved designs have come upon us almost as rapidly as changes in clothing styles with the result that nearly every power plant in the country could make some changes in equipment that would benefit the economy of the plant. The engineer's opportunity to make recommendations profitable to plant owners has seldom been greater than it is today.

THERMOMETERS can be calibrated by a number of fixed points ranging from the boiling point of oxygen at minus 297 deg. F., to the melting point of platinum at 3191 deg. F.

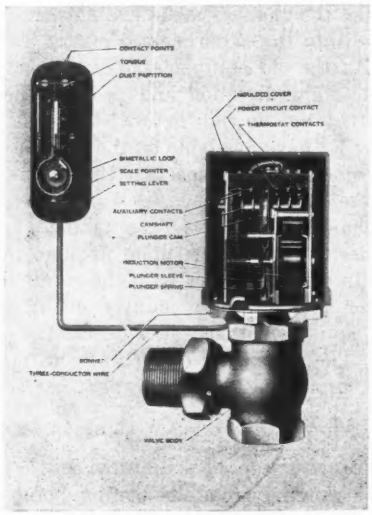
Power Plant Engineering Developments and News

Electric System of Temperature Control

FOR CONTROL of room temperatures by electrical methods, the new electric system illustrated here has recently been placed on the market by Barber-Colman Co., Rockford, Ill. The illustration shows room thermostat and motor operated valve as usually connected, with the valve in the closed position. As the temperature of the air near the thermostat falls, the bimetallic loop contracts slightly and the tongue moves over to make contact with the right-hand point. This closes the motor circuit and the motor operates to raise the valve plunger by means of a train of gears and a two-roller cam.

Soon after each cycle starts, a cam short-circuits the thermostat and closes the power circuit to the motor, holding it closed for the balance of the cycle and breaking it when the cycle is complete. Thus the thermostat carries the motor current for only a small fraction of the cycle.

During the valve cycle, the camshaft changes the contacts so that when the cycle is completed the motor will not operate again until the temperature rises, when the tongue of the thermostat moves over and makes contact with the left-hand point. The closing cycle then occurs and the valve plunger is pushed down, leaving the valve in the closed position. Each cycle takes about 7 sec. The equipment is designed for 25 v., supplied usually by a transformer from the 115-v. a.c. line. By means of auxiliary contacts, a number of valves in a room may be arranged for control from one thermostat so that the valves will open and close in sequence.



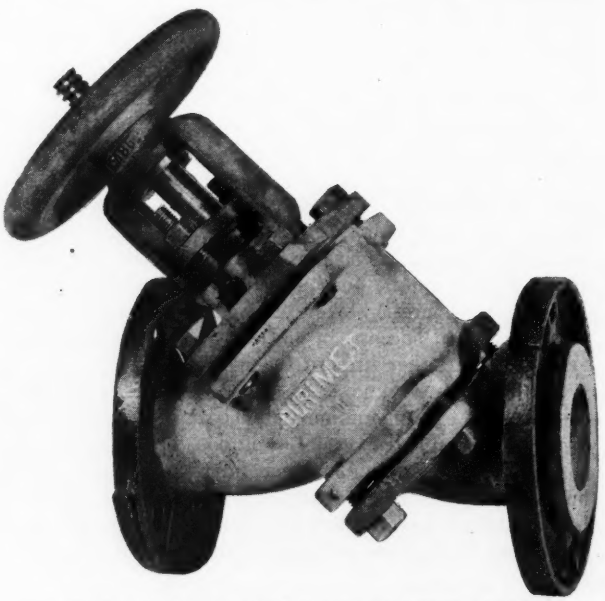
ROOM THERMOSTAT ACTUATES MOTOR OPERATED BY RADIATOR VALVE

Corrosion Resistant Alloy Valves

POSSESSING several features that makes it of special interest to those processes using corrosives, a new alloy steel Y valve is just being put on the market by the Duriron Co., Dayton, O. The valve is a nickel-chrome-silicon alloy steel, highly resistant to sulphuric acid at all concentrations and temperatures as well as to many other corrosives.

With the exception of the cast-iron hand wheel, all parts of the valve are made of this special alloy, trademarked Durimet. The valve disc is full-floating, permitting a different seating each time the valve is used with consequently more even wearing and less chance for leakage from deposits. The valve seat is reversible and removable for regrinding if necessary. The lower half of the valve can be turned 180 deg., making it an angle valve, if desired.

Another feature worthy of note is that the packing gland can be repacked when necessary with the valve wide open, as a cast-in shoulder takes the pressure.



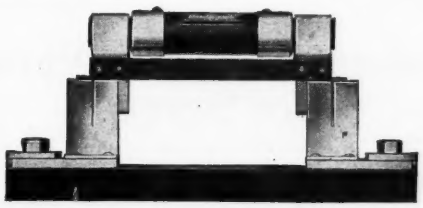
NEW DURIMET VALVE OF THE DURIRON CO.

Tensile strength is approximately 75,000 lb., with a yield point of 32,000 lb. Tough, strong, and durable, the valve has already found many applications where resistance to corrosion coupled with comparatively high pressures and sudden temperature changes is required. It is made in sizes from ¾ to 6 in.

Fuse Reducer

DESIGNED to prevent over-fusing and thus to reduce fire hazards, possibility of burn-outs and maintenance cost, the fuse reducer shown in the accompanying illustration has recently been placed on the market by the Ideal Commutator Dresser Co., Sycamore, Ill. These reducers are designed to permit the installation of the proper size fuse to protect wires of feeder and branch circuits to prevent overheating and deterioration of the insulation.

Many main switchboards and sub-distribution boards are often installed with fuse gaps of greater capacity than required. The size of wires connected to them are based on the actual load which may be less than that



FUSE REDUCER, 200 TO 100 AMP., 250-V. SPACING

contemplated. In such a case the fuse gap will accommodate a fuse of greater capacity than the safe capacity of the wire and the reducer can be used to obtain proper fusing.

These reducers are also intended to be used to protect motors and other devices against burn-outs in case the size of the motor and its control switch is reduced. Further to secure the advantages of rugged construction in some of the larger types of switches, the manufacturer states that by using the fuse reducers, proper protection is afforded with switches larger than those necessary at the time of installation but which may be needed later to carry increased loads.

Abrasion and Corrosion Resistant Plastic Rubber

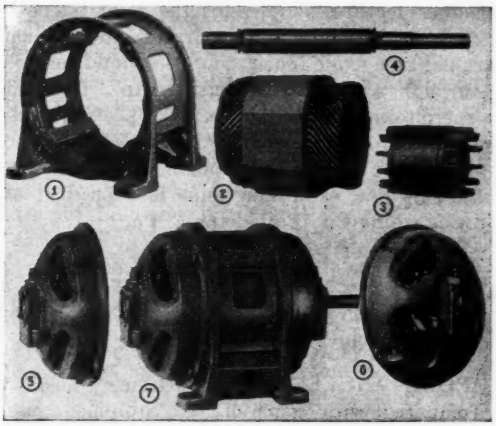
RUBBER will resist most forms of corrosion better than anything else, and for what is said to be the first time in industrial experience, it may now be had and applied in paste form. Colvulc, a plastic rubber compound made by the Hitchcock Co., Inc., 461 Park Square Bldg., Boston, Mass., may easily be attached to metal, wood, concrete, rubber or fabric by repair men. It spreads like soft putty and cures at room temperatures into an elastic sheet of true rubber protection.

As a lining for tanks, tank cars, vats and buckets, or a covering for pipes, girders, skirt boards and conveyor belts, Colvulc provides a protection that no amount of expansion, contraction or stress will crack or dislodge. It will withstand extremes of heat and cold, does not become hard and brittle and retains its elasticity indefinitely.

Motor Has Separable Electrical and Mechanical Parts

IN THE DESIGN OF the new Westinghouse W-frame type CS squirrel cage induction motor, the manufacturers have incorporated an important innovation in motor design: making the different parts of the motor as entirely separate units. Having adopted the separate parts idea, the company has only to keep the number of standardized parts in stock to be able to build, on short notice, a motor for a specific application. The new design makes maintenance simpler and less expensive, because damaged electrical parts can be replaced without replacing or rewinding the motor.

In the new induction motor the stator core containing its winding is pressed into the motor frame. When it becomes necessary to replace a damaged winding, the old core with its winding is pressed out as a unit by means of an ordinary arbor press, and a new "pre-wound" core pressed in; then, after the motor is reassembled, it is ready for use, the entire operation of replacing the damaged winding usually having been performed in less than an hour.



PARTS OF NEW MOTOR

One. Standard cast frame. 2. Standard pre-wound core. 3. Standard die-cast rotor. 4. Sealed sleeve bearing shaft. 5 and 6. Sealed sleeve bearing jacket. 7. Assembled motors.

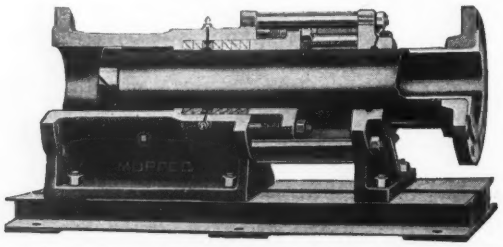
Like the stator core and its winding, the rotor is a complete separate unit; and both the rotor and the stator core and winding can be supplied as such for built-in motor or repair purposes. This feature makes it possible to vary the electrical characteristics, using the same set of mechanical parts; and, with a given set of electrical parts, the mechanical construction can be changed in almost numberless combinations.

The separate-frame construction makes it possible to supply any one of a number of different types of frames to meet the needs of the customer. The brackets are bolted to the frame with a ring-groove fit that automatically and permanently sets the air gap and alines the bearings, simplifying reassembly.

OVERMOTORING, a tendency of many engineers to play safe, is not only expensive in first cost but in operating cost as well. It results in low motor efficiency and low power factor.

Heavy-Duty Expansion Joint

IN THE ACCOMPANYING illustration, details of the construction of the Murfco heavy-duty expansion joint, recently placed on the market, are clearly shown. The principal feature claimed for this joint is that it has a permanently fixed extension guide rigidly attached to the body of the joint proper. This construction is designed to preclude any chance of misalinement and to



SECTION SHOWING DETAILS OF MURFCO EXPANSION JOINT

preserve the packing in its position concentric with the sleeve itself. The object of this is to eliminate leakage and facilitate repacking of the joint.

Another feature claimed for the joint is the lubricating system. Alemite fittings are provided to conduct a charge of zinc oxide lubricating compound under pressure through a metal distributing ring, to form the lubricant into a thin film between the packing and sliding sleeve. This is intended to impregnate the packing and to preserve it in a soft, pliable and resilient condition. This new expansion joint is a product of the Murphy Machine Co., Philadelphia, Pa.

Stellite to Increase Life of Needle Valves

NEEDLE VALVES may be extremely small when compared with some of the equipment used in hydroelectric power plants. But efficiency of output of an impulse wheel depends to a considerable degree upon

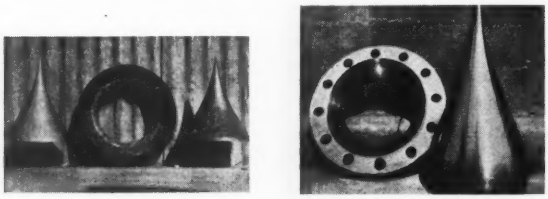


FIG. 1. IN CENTER, HARD-FACED THROAT RING READY FOR GRINDING; AT RIGHT, WORN BRONZE NEEDLE VALVE; AT LEFT, HARD-SURFACED NEEDLE VALVE, OF SAME LENGTH OF SERVICE

FIG. 2. HAYNES STELLITED NEEDLE VALVE AND NOZZLE

the proper working of this part. The precision with which the needle point and valve seat are machined and their accuracy during operation may determine in part the losses sustained between input power and output.

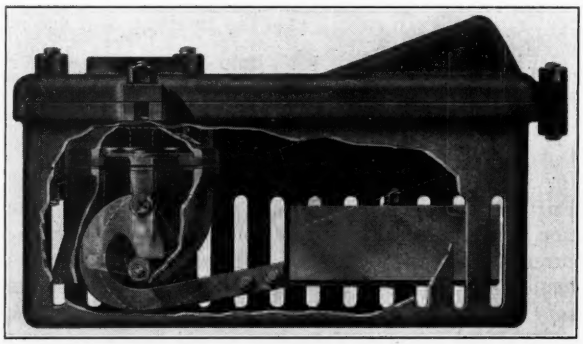
Average life of an ordinary needle valve, it is stated, is between six weeks and three months. It is then worn so that the efficiency of the machine has been materially reduced in some cases. As considerable time and expense may be required to replace a valve, two power companies operating in the far West tried hard-surfacing these parts in order to prolong their life. Previous to this experiment, one company used bronze needles and seats while the other used tool steel.

In both cases, steel was used as the base metal for the hard-facing. The hard-surfacing material, Haynes Stellite, was applied in the form of welding rod, using the oxy-acetylene process. The inside of the valve seat and the entire needle were coated as shown by the throat ring in Fig. 1. The surface was then ground down to the desired shape as in Fig. 2.

On the right in Fig. 1, is a bronze needle worn to such an extent as to be unfit for further duty and on the left a hard-surface needle that had been in service for the same length of time as the bronze needle. The hard-faced needle showed no signs of wear at all, it is stated. When it was examined again at the end of six months, it was still practically as good as new. The total service life was found to be one year or from four to nine times that of ordinary tool steel or bronze parts, according to Haynes Stellite Co. of New York.

Automatic Suction Valves for Sumps

FOR USE in cases when pumping must be done from several sumps located reasonably close together even though at different levels, an automatic suction valve



PHANTOM VIEW SHOWING ACTION OF AUTOMATIC SUCTION VALVE

recently placed on the market is designed to make it possible to employ a single pump to empty all of the sumps. This valve is a device designed to keep the suction line tightly closed until there is enough water in the sump to warrant opening the line, thus the pump cannot draw air into the suction line at any point and will be using full capacity where it is most needed.

This valve, a recent product of the LaBour Co., Inc., Elkhart, Ind., is float controlled but not float operated. As shown in the illustration, the valve is closed and locked in that position by the weight of the float connecting through the float arm against the roller at the bottom of the valve stem. As soon as sufficient water, about 3 in., flows into the sump, the float is lifted and the cam rotates out of the way of the roller. The suction of the pump then opens the valve and draws the water out of the sump.

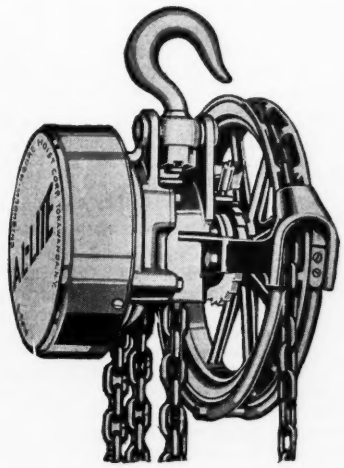
This operation continues until the water drops low enough, about 1½ in., to permit air to enter in the bottom of the valve skirt. By this time, the float is suspended in the air above the water because the cam cannot pass the roller. When air enters the valve skirt, it immediately rises to the top and passes through the valve opening, which allows the valve to drop momentarily when the impact of water ceases. This permits the float to drop and lock the valve in closed position.

The opening and closing of the valve are designed to be by snap action to reduce tendency for dirt to accumulate, to eliminate wiredrawing, chattering and pounding. When the pump is not in operation, the valve also acts as a foot valve.

The automatic suction valve is designed to be compact and to be installed in any location. The exterior casing of a 2-in. valve is 8½ in. high and 10 by 15 in. in area. If corrosive water is to be handled, all parts of the valve including the casing may be made of special material to resist the corrosive action, if desirable, but usually it is sufficient to confine these materials to the valve and the valve seat.

Chain Hoist Made of Aluminum

WHAT IS CLAIMED to be the first aluminum-alloy chain hoist, the Al-Lite, has recently been announced. This unit is designed to be one-third lighter than other chain hoists, to have fewer parts, and to provide great strength and high efficiency. Only certified Alcoa aluminum alloys are used.



AL-LITE CHAIN HOIST

Some of the features claimed for the new Al-Lite include lightness, strength, portability, Alemite lubrication, simple, rugged design, easy accessibility, hardened and ground ball bearings, planetary type gears, dust-proof housing, adjustable brake for security and positive action, high efficiency, bright aluminum finish, corrosion resistant, Inswell chain.

Because one man can carry it and hang it in place, Al-Lite, it is claimed, should cut maintenance costs, eliminate hazards and save considerable time. It is a product of Chisholm-Moore Hoist Corp., Tonawanda, N. Y.

Southwest Power Conference at Kansas City, Sept. 7 to 11

MEMBERS OF MANY TECHNICAL and engineering organizations will gather at Kansas City, Mo., during the week of September 7 to take part in the Southwest Power Conference. The Kansas City Regional meeting of the American Society of Mechanical Engineers is to be held at this time, also the annual convention of the National Association of Power Engineers, meetings of several technical committees of the National Electric Light Association, meetings of the municipal utilities organizations of several states and a convention of coal dealers.

Additional data regarding these meetings and information on transportation, hotel reservations and so on may be obtained from B. J. George, Kansas City Power & Light Co., Kansas City, Mo., chairman of publicity for the combined events. B. W. Crenshaw, of Henrici-Lowry Engineering Co. of Kansas City, Mo., is chairman of the publicity committee, Kansas City section, A.S.M.E.

The program of the Kansas City Regional meeting of the A.S.M.E. includes technical meetings to be held in the new Kansas City Power & Light Bldg., sightseeing trips and entertainment features, conferences of local sections, delegates, and so on.

On Tuesday, September 8, at 9:30, a session on fuels will include a paper on Improvements in Mining and Preparing Strip Coal in the Southwest, by L. Russell Kelce, and another on Coal as a Basic Fuel, by H. Kreisinger. A simultaneous session on Oil and Gas Power includes the following papers: A Speed Characteristic for Oil Engines, V. L. Maleev; Diesel Engines as Peak Load Units, S. A. Hadley; and Developments in Internal-Combustion Engines for Use in the Oil Industry, H. F. Shepherd. A meeting on aeronautics will be held at the same time. At 12:15 there will be a joint luncheon with the Engineers Club which will be addressed by Captain Theo. Wyman, Jr., speaking on the Missouri River. At 2:30 p.m. there will be sightseeing trips, golf and bridge at the Hillcrest Country Club and industrial inspection trips.

On Wednesday, September 9, at 9:30 a.m. a session on Power will include the following papers: Flour Milling and Power Requirement, Grover C. Meyer; 1400-lb. Pressure Boiler and Turbine Operation at Northeast Station, J. A. Keith; Diphenyl Oxide, by John J. Grebe. A simultaneous meeting on Petroleum and another on Aeronautics will be held at this time. At 12:15 there will be a joint luncheon with the Chamber of Commerce. At 2:30 p. m. there will be an industrial inspection trip, also golf and bridge, and at 7:00 p. m. a banquet and dance at the Kansas City Athletic Club. Special entertainment features for the ladies have been provided.

Industrial inspection trips will include Kansas City Water Works, Northeast Power Plant of the Kansas City Power & Light Co., Sheffield Steel Corp., Standard Oil Co., Colgate-Palmolive-Peet Co., Washburn-Crosby Flour Mill, Fairfax Airport and Municipal Airport.

At the same time as the meetings of the various organizations mentioned above, a power show is to be held at which a large number of manufacturers plan to display all types of power and mechanical engineering equipment.

Death of Homer Eldredge Niesz

HOMER ELDREDGE NIESZ, manager of industrial relations of the Commonwealth Edison Co. of Chicago, Ill., and a pioneer in the development of electric light and power in Chicago, died at the Illinois Central Hospital August 7, in his 64th yr. He had been connected with the Commonwealth Edison Co. and the companies which preceded it from his boyhood almost until his death and had worked up from lineman to the office of manager of industrial relations that he had held for the last 10 yr. He was also an active force in the National Electric Light Association and had served as chairman of several of that organization's leading committees. He resigned from the chairmanship of the Industrial Relations Committee of the N. E. L. A. only a week or two ago but retained his membership therein.

HOMER ELDREDGE NIESZ

Mr. Niesz was born in Canton, Ohio, and was graduated from Mount Union College in 1886. Shortly after his graduation, he came to Chicago and started as a lineman of the old Chicago Edison Co. After two years of various work he was appointed assistant superintendent of construction and in 1889 became assistant to the general manager. Other promotions followed, such as assistant to the vice president in charge of construction and in 1921 he was made manager of industrial relations.

Mr. Niesz was an active member of most of the business and technical organizations connected with the electric light and power industry. He had served as president of the National Safety Council, Western Society of Engineers, The Electric Club of Chicago and the Chicago Engineers' Club. He took a prominent part in the work of the Electric Association of Chicago, the American Institute of Electrical Engineers, the Illuminating Engineering Society, the Industrial Relations Association of America and, as previously stated, the National Electric Light Association. He was also a member of the Ohio Society of Chicago, the Chicago Athletic Association and the South Shore Country Club.

For several years Mr. Niesz served as manager of the Chicago Electrical Show (now discontinued) and he also served as chairman of the Chicago Section of the Electric Vehicle Association for several years. In 1914 and 1915 he served as the Reigning Jupiter of the Jovian Order, at that time a large national society composed of members of the electric industry.

News Notes

FOR THE NEW POWER PLANT of the city of Vernon, Calif., a contract has been awarded to Hooven, Owens, Rentschler Co., of Hamilton, Ohio, for five Diesel engines with a total capacity of 35,000 hp., according to a recent report. The announcement states that the engines are of the Hamilton M.A.N. type, double-acting, two-cycle, with airless injection. Each unit has eight cylinders of 24-in. bore and 36-in. stroke and will drive a 5000-kw., 6900-v. generator at 167 r.p.m. Scavenging air will be supplied to the engines from separate blowers independently operated. Generators, exciters and necessary pumps are to be supplied by Allis-Chalmers Mfg. Co., Milwaukee, Wis., and the blowers by American Brown Boveri Co., now a subsidiary of Allis-Chalmers Mfg. Co.

HERBERT M. SHARP, assistant superintendent of Charles R. Huntley Stations One and Two of the Buffalo General Electric Co., has been promoted to the position of superintendent.

JAMES O. G. GIBBONS, consulting engineer of Newark, N. J., has moved his office from 207 Market St. to 45 Clinton St.

MAXFIELD PEASE has resigned from the Dravo-Doyle Co., Philadelphia, Pa., to become associated with the Automatic Cone Valve Co., Chicago, Ill.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has acquired the principal assets of the American Brown Boveri Co. Inc. and the capital stock of Condit Electrical Manufacturing Corp. of Boston, Mass. By this purchase, Allis-Chalmers secures several new lines of equipment such as mercury arc rectifiers, blowers, electric furnaces and oil circuit breakers. After completing the manufacture of goods on order at Camden, N. J., the operations now carried on by the American Brown Boveri Co., Inc. will be segregated. The large apparatus departments, with substantially the same personnel, will be transferred to the Allis-Chalmers plants at Milwaukee and Pittsburgh while the remainder will be moved to the plant of the Condit Electrical Mfg. Corp. at Boston. The corporate entity, organization, plant and product of the Condit Electrical Mfg. Corp. will be retained as at present.

H. A. KULJIAN, consulting engineer, formerly with The Viscose Co., announces the opening of offices at 717-18 Harrison Building, Philadelphia, Pa. Mr. Kuljian has had long experience in power plant work and will specialize in Power plants, Industrial plants, Combustion problems and heating and ventilating.

AT THE BOILER PLANT of Spreckels Sugar Co., Spreckels, Calif., natural gas fuel from the Kettleman Hills district is now being burned. Boilers are rated at 7500 hp. but operate usually at about 200 per cent of rating or 15,000 hp. According to data from J. W. Adams, plant engineer, they consume over 19,000,000 cu. ft. of gas every 30 days.

J. F. OWENS, PRESIDENT, Oklahoma Gas and Electric Co., announces the appointment of Robert C. Coffy as manager of the eastern division of the company with headquarters in Muskogee, and the election of W. S. Van Sickel to succeed Mr. Coffy as vice president and general manager of the Mississippi Valley Power Co. and president of the Fort Smith Traction Co. Mr. Coffy succeeds W. H. Crutcher who died recently. Mr. Coffy has been associated with the Byllesby organization since 1908 when he joined the Oklahoma Gas and Electric Co. Mr. Van Sickel has been associated with the Byllesby organization since 1907 and until recently served as assistant general manager in charge of operation of the Fort Smith Traction Co. and the Mississippi Valley Power Co.

CAPTAIN WALTER M. MCFARLAND, manager of the Marine Department of The Babcock & Wilcox Co., will retire from active service September 1. The announcement of this change states that Captain McFarland, by reason of ill health, asked to be retired from the service of the company on September 1. After his graduation from the U. S. Naval Academy in 1879, Captain McFarland served on naval vessels in various parts of the world and was at one time principal assistant to Admiral Melville, who was then engineer-in-chief of the United States Navy. He held the rank of chief engineer and in 1897 was a member of the board to reorganize the personnel of the Navy, which was presided over by President Roosevelt, at that time assistant secretary of the Navy. He resigned from the Naval service in 1899 to become vice president of Westinghouse Electric & Manufacturing Co., which position he held until April, 1910, when he became Manager of the Marine Department of The Babcock & Wilcox Co.

He was Secretary of the Division of Marine Engineering at the International Engineering Congress held in connection

with the World's Fair, in 1893, at Chicago. He is a past president and honorary member of the Society of Naval Architects and Marine Engineers, a past vice president of the American Society of Mechanical Engineers and a member of the Council of the American Society of Naval Engineers. He is president of Webb Institute of Naval Architecture and has lectured at many colleges and universities, including the United States Naval War College.

C. E. STEPHENS, vice president, Westinghouse Electric and Manufacturing Co., has announced the appointment of T. R. Langan as Northeastern District Manager of the Westinghouse organization with headquarters in New York City. Mr. Langan has been with the Westinghouse Co. for more than 20 yr. Starting as an apprentice in the engineering department, he advanced through the construction, service and sales departments of the company to the office of manager of the Transportation Division of the Northeastern District and later to assistant northeastern district manager, which office he held at the time of his promotion. Before going to the New York Office, Mr. Langan served the Westinghouse Co. in Philadelphia, Baltimore and Buffalo and was manager of the Syracuse Office.

AS A RESULT of research work extending over several years at the Chicago Heights plant of the American Manganese Steel Co., patents have been granted to the company covering the AMSCO Nickel Manganese Steel welding rod for the welding, repair and reclamation of manganese steel castings, a welding rod that would leave a deposit equivalent in analysis and physical properties to heat-treated Manganese Steel.

ELLISON DRAFT GAGE CO., Chicago, Ill., announces the appointment of Smiley Equipment Co., 102 Carmen's Building, Kansas City, Mo., as its exclusive representative in eastern Kansas and western Missouri; also the Power Equipment Co., 5473 Delmar Blvd., St. Louis, Missouri, in the eastern Missouri territory.

Books and Catalogs

FOREIGN DEVELOPMENTS are discussed in publication No. 131 just issued by Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City, price 60 cents to members, 90 cents to non-members.

In general, the trend of foreign power plant development is toward higher pressures and temperatures, the utilities favoring the latter while the industrials are adopting both.

The American viewpoint of the Continental situation is presented in a composite statement of several engineers who attended the World Power Conferenec in Berlin.

The Loeffler system of steam generation is receiving a thorough trial at Vitkovice, Czecho-Slovakia. Progress in England indicates a design tendency toward increased capacities of equipment. Particular attention is directed toward the elimination of dust and fumes.

Efforts of equipment manufacturers in designing apparatus for the utilization of the poorer grades of coal are meeting with success in Germany. Turbine and boiler capacities are increasing as are the pressures and temperatures. The peak load and stack discharge problems are receiving much attention.

Considerable material is presented covering the design of boilers, turbines and boiler feed pumps for pressures above 600 lb. and apparatus for the removal of dust from stack gases.

SUMMARY OF PUBLIC COMMISSION RULES and Regulations for Electricity Meters, has just been issued as publication No. 132 by the Meter Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York, price 25 cents to members and 40 cents to non-members.

Rules and regulations for Electricity Meters have been adopted in 23 states and the District of Columbia. To show clearly the similarities and differences in the rules so far adopted by State Commissions, abstracts of these rules have been made and are included herewith under appropriate headings.

The purpose of this report is to acquaint those interested in meter practices with the rules in effect throughout the country. It is hoped that where differences exist between states an effort will be made to effect such changes as will ultimately provide standardization of service rules for all states.

CUT COSTS ON LOW PRESSURE STEAM LINE INSTALLATIONS is the title of a recent bulletin describing how this may be done with Adsco Red Diamond brand casing. This bulletin has just been published by American District Steam Co., North Tonawanda, N. Y.

SEMET-SOLVAY PIPING AND VALVES are described in bulletin No. 44, a 48-page publication just issued by Semet-Solvay Engineering Corp., 40 Rector St., New York City. Tables of standards are given, together, with suggestions for efficient planning of piping, diagrams of operating arrangements for gate valves and much engineering information, with a complete index.

JONES HERRINGBONE-MAAG SPEED REDUCERS, series DW, are described and illustrated in detail in bulletin No. 51 just issued by W. A. Jones Foundry & Machine Co., 4401 Roosevelt Road, Chicago, Ill.

PERFECT OIL RETAINERS are described in detail with tables of dimensions, details of construction of the parts, and detailed drawings showing how they are used, in a new 64-page bulletin issued by the Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago, Ill.

NICHOLSON Industrial Steam Trap for pressures from vacuum to 100 lb., style A up to ¾ in. and style B ½ to 2 in. inclusive, is described in new bulletin No. 531 by W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa.

IDEAL SYSTEM OF LUBRICATION, a constant and controlled system for applying grease to bearings, is described in a well-illustrated 32-page booklet just issued by Ideal Lubricator Co., Packard Bldg., Philadelphia, Pa.

CONTROLLING THE WHEELS OF INDUSTRY is the title of a new 60-page publication showing the various applications in industry of Johns-Manville friction materials. This describes and illustrates the use of these materials on such equipment as cranes, brake bands, machine tools, paper machines and the like. It is published by Johns-Manville Corp., 292 Madison Ave., New York City.

POWER FILTER UNIT designed to convert alternating current into non-pulsating, humless, direct current for use on telephones, sound-on-film, public address systems, inter-communicating systems, clock and signal systems, magnetic chuck operation and elevator control is described in a new bulletin issued by the Power Filter Division, Square D Co., 6060 Rivard St., Detroit, Mich.

COMPLETE DESCRIPTION of the units which compose a modern recording thermometer is given in a bulletin just published by the Foxboro Co. of Foxboro, Mass. This bulletin No. 69, a 40-page publication, describes the vapor tension type and gas filled thermometers. It contains engineering information on bulbs, sockets, helical tubes and instrument boards.

SPECIAL PROCESS EQUIPMENT is the title of a new bulletin S-9 issued by The Babcock & Wilcox Co., 85 Liberty St., New York, describing the fabrication of riveted and welded pressure vessels, tubular equipment, penstock piping, bends and forgings. All these products are illustrated by photographs and descriptions of typical installations. A section of the booklet is devoted to a brief discussion of a new welding technique previously described in Power Plant Engineering. The bulletin also discusses the production of alloy castings including the usual heat resisting alloys, the so-called stainless alloys, Nirosta KA_2, high chrome-iron and intermediate alloys to resist corrosion and withstand high temperatures. B. & W. No. 80 Insulating Firebrick is the subject of a new bulletin R-2 issued by the company. It discusses a new firebrick with insulating properties, an entirely new building material for furnace work, which, the company states, has not only insulating qualities better than the majority of high quality insulators but refractory characteristics that compare favorably with any high grade firebrick. These characteristics are illustrated by means of curves and sketches and calculations.

SAFEGUARDING the Gas Compressor by Means of the Maihak Indicator is the title of a new bulletin, No. 3264, published by Bacharach Industrial Instrument Co., 7000-6 Bennett St., Pittsburgh, Pa. showing how the indicator can be used to keep the gas compressor in best possible operating condition.

STERLING-DRIVEN Generator Sets are described and illustrated and their application shown in a new catalog, beautifully printed in colors, of the Sterling Engine Co., Buffalo, N. Y. Appearance of the various sizes, from 70 up to 565 hp. is well shown and over-all dimensions given. Uses of the 6-cylinder and 8-cylinder sets for pumping, bridge handling, standby power, residence lighting and power, industrial plants and motored railroad coaches are shown. An insert describes an unique installation of an 8-cylinder set mounted as power plant on a traveling mooring mast for Zeppelin air ships to be used at the plant of the Goodyear-Zeppelin Corp., Akron, Ohio. The mast mounted on tractors serves as an anchorage also to tow the ship to hangar or other location.

Machinery, Equipment and Supplies Used In The Production, Transmission and Utilization of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear

AIR COMPRESSORS
De Laval Steam Turbine Co., Trenton, N. J.
Nash Engrg. Co., S. Norwalk.
Pennsylvania Pump & Compressor Co., Easton, Pa.
Worthington Pump & Machy. Corp., New York.

AIR PREHEATERS
Air Preheater Corp., The, N. Y.
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y.
Edge Moor Iron Co., Edge Moor.
Foster Wheeler Corp., New York.

AIR SEALS, Kiln
Edge Moor Iron Co., Edge Moor.

ALARMS, Feedwater Concentration
Leeds & Northrup Co., Phila.

ALARMS, High and Low Water
Anderson Co., V. D., Cleveland.
Huyette Co., Paul B., Phila.
Northern Equip. Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio.
Yarnall-Waring Co., Phila.

ANTI-CORROSIVE COATINGS
Master Mechanics Co., Cleveland.

ASH BIN GATES AND DOORS
Allen-Sherman Hoff Co., Phila.

ASH HANDLING SYSTEMS
Combustion Engrg. Corp., N. Y.
Stephens-Adamson Mfg. Co., Aurora, Ill.

BEARING TESTERS
Burgess Parr Co., Chicago.

BEARINGS, Tapered Roller, Radial & Thrust
Timken Roller Bearing Co., Canton.

BELT CONVEYORS
Stephens-Adamson Mfg. Co., Aurora, Ill.

BELT DRESSING
Standard Oil Co. (Indiana), Chicago, Ill.

BELTING
Pioneer Rubber Mills, San Francisco.

BLOWERS, Fan and Furnace
Air Preheater Corp., The, N. Y.
De Laval Steam Turbine Co., Trenton, N. J.
Wing Mfg. Co., L. J., New York.

BLOWERS, Forced Draft, Portable, Pressure and Pulverized Coal
Wing Mfg. Co., L. J., New York.

BLOWERS, Tube
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Corp., Detroit, Mich.

BLOWERS, Turbine
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLE CONTRACTORS
Engineer Co., The, New York.

BOILER BAFFLES
Engineer Co., The, New York.
Quigley Co., Inc., New York

BOILER BLOW DOWN SYSTEMS
National Aluminate Corp., Chicago, Ill.

BOILER COATINGS
Master Mechanics Co., Cleveland.

BOILER COMPOUNDS
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.

BOILER FEED WATER PURIFYING APPARATUS
Permutit Co., New York, N. Y.

BOILER SETTING CEMENT
Hays Corp., Michigan City, Ind.
Huyette Co., Paul B., Phila.

BOILER SETTINGS
Engineer Co., The, New York.
Rust Engrg. Co., Pittsburgh.

BOILER TUBE CLEANERS
General Specialty Co., Buffalo.
Huyette Co., Inc., Paul B., Phila.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

BOILERS, Power and Heating
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Kingsford Fdry. & Mach. Co., Oswego, N. Y.
Springfield Boiler Co., Springfield, Ill.
Union Iron Works, Erie, Pa.
Vogt Mach. Co., Inc., Henry, Louisville.
Wickes Boiler Co., Saginaw.

BOILERS, Return Tubular
Erie City Iron Works, Erie, Pa.
Frick Co., Waynesboro, Pa.

BOILERS, Semi-Portable
Erie City Iron Works, Erie, Pa.

BOILERS, Waste Heat
Babcock & Wilcox Co., N. Y.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Wickes Boiler Co., Saginaw.

BOILERS, Water Tube
Babcock & Wilcox Co., N. Y.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Springfield Boiler Co., Springfield, Ill.
Wickes Boiler Co., Saginaw.

BREECHINGS
Connery & Co., Inc., Phila.

BUCKET ELEVATORS
Stephens-Adamson Mfg. Co., Aurora, Ill.

CARRIERS, Pivoted Bucket
Stephens-Adamson Mfg. Co., Aurora, Ill.

CASTINGS
Burgess Parr Co., Chicago.
Fuller Lehigh Co., N. Y.
Neemes Fdry., Inc., Troy, N. Y.

CASTINGS, Steel
Springfield Boiler Co., Springfield, Ill.

CEMENT, Iron
Smooth-On Mfg. Co., Jersey City.

CEMENT, Refractory, Acid Proof, Furnace and High Temperature
Babcock & Wilcox Co., N. Y.
Quigley Co., Inc., New York.

CHAIN WHEELS
Babbitt Steam Spec. Co., New Bedford, Mass.

CHEMICALS, Water Treating
National Aluminate Corp., Chicago, Ill.
Permutit Co., New York, N. Y.

CHIMNEYS
American Chimney Corp., N. Y.
Rust Engrg. Co., Pittsburgh.

CIRCUIT BREAKERS
I-T-E Circuit Breaker Co., Phila.

CLEANING COMPOUND
Dearborn Chem. Co., Chicago.

COAL AND ASH HANDLING MACHINERY
Allen-Sherman-Hoff Co., Phila.
Fairbanks, Morse & Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.

COAL BUNKERS, Cast Iron, Catenary
Allen-Sherman-Hoff Co., Phila.

COAL CARBONIZING APPARATUS
Combustion Engrg. Corp., N. Y.

COAL CRUSHERS
American Pulverizer Co., St. Louis, Mo.
Pennsylvania Crusher Co., Phila.
Stephens-Adamson Mfg. Co., Aurora, Ill.

COAL STORAGE EQUIPMENT
Allen-Sherman-Hoff Co., Phila.
Stephens-Adamson Mfg. Co., Aurora, Ill.

COAL TESTING APPARATUS
Burgess Parr Co., Chicago.

COCKS, Air and Steam
Dart Mfg. Co., E. M., Providence, R. I.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Lonergan Co., J. E., Phila.
Powell Co., Wm., Cincinnati.
Williams Valve Co., D. T., Cincinnati, O.

COILS AND BENDS
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
National Pipe Bending Co., New Haven, Conn.

COMBUSTION (CO_2) RECORDERS
Brown Inst. Co., Philadelphia.
Hays Corp., Michigan City, Ind.
Huyette Co., Paul B., Philadel-
Leeds & Northrup Co., Phila.
Permutit Co., New York, N. Y.
Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago, Ill.

COMBUSTION CONTROL SYSTEM
Bailey Meter Co., Cleveland.
Engineer Co., The, New York.
Leeds and Northrup Co., Phila.

COMBUSTION ENGINEERS
Engineer Co., The, New York.

COMPOUND PIPE JOINT
Smooth-On Mfg. Co., Jersey City.

COMPRESSORS, Ammonia
Frick Co., Waynesboro, Pa.

CONDENSER TUBE CLEANERS
Lagonda Mfg. Co., Springfield, O.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

CONDENSERS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Anderson Co., V. D., Cleveland.
Elliott Co., Jeannette, Pa.
Foster Wheeler Corp., New York.
Frick Co., Waynesboro, Pa.
Manistee Iron Works Co., Manistee, Mich.
Pennsylvania Pump & Compressor Co., Easton, Pa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Machy. Corp., New York.

CONVEYORS
Stephens-Adamson Mfg. Co., Aurora, Ill.

COOLERS, Air, Oil and Water
Wheeler Mfg. Co., C. H., Phila.

COOLING SYSTEMS
Schubert-Christy Corp., Affton, Yarnall-Waring Co., Phila.

COOLING TOWERS
Binks Mfg. Co., Chicago, Ill.
Foster Wheeler Corp., New York.
Schubert-Christy Corp., Affton.
Wheeler Mfg. Co., C. H., Phila.

COUNTERS, Revolution
Lonergan Co., J. E., Phila.

COUPLINGS, Flexible
Terry Steam Turbine Co., Hartford, Conn.

COUPLINGS, Union
Dart Mfg. Co., E. M., Providence.

CRUSHING AND GRINDING MACHINERY
American Pulverizer Co., St. Louis, Mo.
Pennsylvania Crusher Co., Phila.

DE-AERATORS
Elliott Co., Jeannette, Pa.

DESUPERHEATERS
Babcock & Wilcox Co., N. Y.
Elliott Co., Jeannette, Pa.

DRYERS, Rotary & Waste Heat
Fuller Lehigh Co., N. Y.

ECONOMIZERS
Babcock & Wilcox Co., N. Y.
Foster Wheleer Corp., New York.

EJECTORS
Elliott Co., Jeannette, Pa.

EJECTORS, Sewage
Nash Eng. Co., So. Norwalk.

ENGINES, Oil, Gas and Gasoline
Fairbanks, Morse & Co., Chicago, Ill.
McIntosh & Seymour Corp., Auburn, N. Y.
Worthington Pump & Machy. Corp., New York.

ENGINES, Steam
Allis-Chalmers Mfg. Co., Milwaukee.
Elliott Co., Ridgway, Pa.
Kingsford Fdry. & Mach. Co., Oswego, N. Y.
McIntosh & Seymour Corp., Auburn, N. Y.
Troy Engine & Machine Co., Troy, Pa.
Wachs Co., E. H., Chicago.

EVAPORATORS
Foster Wheeler Corp., New York.

EXHAUST HEADS
Burt Mfg. Co., The, Akron, O.
Hoppes Mfg. Co., Springfield, O.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Watson & McDaniel Co., Phila.

FANS, Airplane Type
Schubert-Christy Corp., Affton,

FANS, Exhaust and Ventilating
Wing Mfg. Co., L. J., New York.

FEED WATER FILTERS
Elgin Softener Corp., Elgin, Ill.
Permutit Co., New York, N. Y.

FEED-WATER HEATERS AND PURIFIERS
Cochrane Corp., Philadelphia.
Elliott Company, Jeannette, Pa.
Foster Wheeler Corp., New York.
Hoppes Mfg. Co., Springfield, O.
National Pipe Bending Co., New Haven, Conn.
Scaife & Sons Co., Wm. B. Oakmont, Pa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Machy. Corp., New York.

FEED WATER TREATMENT
Dearborn Chemical Co., Chicago.
Elgin Softener Corp., Elgin, Ill.
National Aluminate Corp., Chicago, Ill.
Permutit Co., New York, N. Y.
Scaife & Sons Co., Wm. B., Oakmont, Pa.

FILTERS, Oil
Anderson Co., V. D., Cleveland.
Burt Mfg. Co., The, Akron, O.

FILTERS, Water
Cochrane Corp., Philadelphia,
Permutit Co., New York, N. Y.
Scaife & Sons Co., Wm., B. Oakmont, Pa.

FIRE BRICK
Babcock & Wilcox Co., N. Y.

FIRE HYDRANTS
Kennedy Valve Mfg. Co., Elmira, N. Y.

FITTINGS, Ammonia
Frick Co., Waynesboro, Pa.

FITTINGS, Flange and Pipe
Kennedy Valve Mfg. Co., Elmira, N. Y.
Limbert & Co., Geo. B., Chicago.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh.
Walworth Co., Boston, Mass.

FLANGES
Dart Mfg. Co., E. M., Providence, R. I.
Limbert & Co., Geo. B., Chicago.
Walworth Co., Boston, Mass.

FLOATS
Anderson Co., V. D., Cleveland.
Reliance Gauge Column Co., Cleveland, O.

FLOW METERS
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., The, Phila.
Republic Flow Meters Co., Chicago.

FLUE CLEANERS
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Corp., Detroit, Mich.
General Specialty Co., Buffalo.
Huyette Co., Paul B., Phila.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.

FLUE GAS ANALYSIS INSTRUMENTS
Hays Corp., Michigan City, Ind.
Permutit Co., New York, N. Y.

FURNACE BOTTOMS, Cast Iron Air Cooled
Allen-Sherman-Hoff Co., Phila.

FURNACE FIRE OBSERVERS
Springfield Boiler Co., Springfield, Ill.

FURNACE SURFACES, Water Cooled
Foster Wheeler Corp., New York.
Fuller Lehigh Co., N. Y.

FURNACE WALLS
Combustion Engrg. Corp., N. Y.

FURNACES, Water Cooled, Refractory
Erie City Iron Works, Erie, Pa.

GAS BURNERS
Peabody Engrg. Corp., N. Y.

GAS COLLECTORS
Hays Corp., Michigan City, Ind.

GASKETS
Crandall Packing Co., Palmyra.
Flexitallic Gasket Co., Camden.
Frick Co., Waynesboro, Pa.
Goetze Gasket & Packing Co., New Brunswick, N. J.
Metallo Gasket Co., New Brunswick, N. J.
Smooth-On Mfg. Co., Jersey City.

GASKETS, Asbestos Steel
Flexitallic Gasket Co., Camden.

GAUGE COCKS
Belfield Co., H., Philadelphia.
Ernst & Co., Newark, N. J.
Huyette Co., Paul B., Phila.
Lonergan Co., J. E., Phila.
Reliance Gauge Column Co., Cleveland, O.

GAUGE GLASSES
Ernst & Co., Newark, N. J.
Jenkins Bros., New York.

GAUGE TESTERS
Ashton Valve Co., The, Boston.

GAUGES, Differential and U-Tube
Hays Corp., Michigan City, Ind.
Ashton Valve Co., The, Boston.

GAUGES, Draft, Liquid Level
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., The, Phila.
Hays Corp., Michigan City, Ind.
Huyette Co., Paul B., Phila.
Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago.

GAUGES, Pressure and Recording
Ashton Valve Co., The, Boston.
Lonergan Co., J. E., Phila.

GAUGES, Water
Anderson Co., V. D., Cleveland.
Ernst & Co., Newark, N. J.
Huyette Co., Paul B., Phila.
Lonergan Co., J. E., Philadel-
Lunkenheimer Co., Cincinnati, O.
Reliance Gauge Column Co., Cleveland, O.

GEARS, Reduction and Double Helical
De Laval Steam Turbine Co., Trenton, N. J.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., Hartford, Conn.

GENERATING SETS
Allis-Chalmers Mfg. Co., Milwaukee.